



INDIAN AGRICULTURAL
RESEARCH INSTITUTE, NEW DELHI.

I. A. R. I. 6.

MGIPC—SI—6 AR/54--7-7-54—10,000.

THE QUARTERLY REVIEW *of* BIOLOGY

VOLUME 15
1940

Published by
THE WILLIAMS & WILKINS COMPANY
BALTIMORE
U. S. A.

THE QUARTERLY REVIEW OF BIOLOGY



RAYMOND PEARL, *Editor*
The Johns Hopkins University

ASSISTED BY

R. W. HEGNER	MAUD DEWITT PEARL
<i>Contributing Editor</i>	<i>Assistant Editor</i>
<i>The Johns Hopkins University</i>	

ADVISORY BOARD

ANATOMY.....	LEWIS H. WEED.....	<i>The Johns Hopkins University</i>
ANTHROPOLOGY.....	A. L. KROEBER.....	<i>University of California</i>
BEHAVIOR AND COMPAR- ATIVE PSYCHOLOGY....	K. S. LASHLEY.....	<i>Harvard University</i>
BOTANY.....	IRVING W. BAILEY.....	<i>Harvard University</i>
CYTOLOGY.....	CHARLES W. METZ.....	<i>University of Pennsylvania</i>
ECOLOGY.....	THOMAS PARK.....	<i>University of Chicago</i>
EMBRYOLOGY.....	E. G. CONKLIN.....	<i>Princeton University</i>
EXPERIMENTAL MORPHOLOGY.....	ROSS G. HARRISON.....	<i>Yale University</i>
GENERAL PHYSIOLOGY {	LAWRENCE J. HENDERSON.....	<i>Harvard University</i>
	G. H. PARKER.....	<i>Harvard University</i>
GENETICS..... {	R. A. EMERSON.....	<i>Cornell University</i>
	T. H. MORGAN.....	<i>California Institute of Technology</i>
GEOGRAPHICAL DISTRI- BUTION AND TAXON- OMY.....	ALEXANDER G. RUTHVEN.....	<i>University of Michigan</i>
PALEONTOLOGY.....	JOHN C. MERRIAM.....	<i>Carnegie Institution</i>
RUSSIAN BIOLOGICAL LITERATURE.....	W. W. ALPATOV.....	<i>University of Moscow</i>
ZOOLOGY.....	FRANK R. LILLIE.....	<i>University of Chicago</i>

CONTENTS

No. 1, MARCH, 1940

	PAGE
The Non-Specificity of the Germ-Layers.....	<i>Jane M. Oppenheimer</i> 1
The Fauna of the Soil.....	<i>Arthur Paul Jacot</i> 28
Sex Differences in Morbidity and Mortality.....	<i>Antonio Ciocco</i> 59
New Biological Books:	
Brief Notices.....	74

No. 2, JUNE, 1940

Auditory Perception in Insects, with Special Reference to the Cock-roach..	<i>Phil Rau</i> 121
Chromaffin Tissue and Paraganglia.....	<i>W. Henry Hollinshead</i> 156
Application of High-Frequency Electrostatic Fields in Agriculture	
<i>P. A. Ark and Willet Parry</i>	172
Sex Differences in Morbidity and Mortality (<i>Concluded</i>).....	<i>Antonio Ciocco</i> 192
Physiology and the Origins of the Menstrual Prohibitions..	<i>M. F. Ashley-Montagu</i> 211
New Biological Books:	
Beginning a New Invertebrate Zoology.....	<i>Thomas Park</i> 221
Brief Notices.....	224

No. 3, SEPTEMBER, 1940

Man: A Constitutional Investigation.....	<i>William B. Tucker and William A. Lessa</i> 265
Regeneration in Protozoa: A Problem in Morphogenesis.....	<i>William Balamuth</i> 290
Acquired Immunity from Plant Virus Diseases.....	<i>W. C. Price</i> 338
New Biological Books:	
Brief Notices.....	362

No. 4, DECEMBER, 1940

The Principle of Cooperation in Behavior.....	<i>William Galt</i> 401
Man: A Constitutional Investigation (<i>Concluded</i>)	
<i>William B. Tucker and William A. Lessa</i>	411
Recent Advances in Antarctic Bio-Geography.....	<i>Alton A. Lindsey</i> 456
New Biological Books:	
Brief Notices.....	466
The Prices of Biological Books in 1940.....	<i>Maud deWitt Pearl and Raymond Pearl</i> 513
Index.....	517

THE QUARTERLY REVIEW of BIOLOGY



THE NON-SPECIFICITY OF THE GERM-LAYERS

By JANE M. OPPENHEIMER

Department of Zoology, University of Rochester, Rochester, N. Y., and Department of Biology, Bryn Mawr College, Bryn Mawr, Penna.

Eigentlich beginnt in jeder dieser drei Schichten eine eigene Metamorphose, und jede eilt ihrem Ziele entgegen; allein es ist jede noch nicht selbstständig genug, um allein das darzustellen, wozu sie bestimmt ist; sie bedarf noch der Hülfe ihrer Gefährtinnen, und daher wirken alle drey, obgleich schon zu verschiedenen Zwecken bestimmt, dennoch, bis jede eine bestimmte Höhe erreicht hat, gemeinschaftlich zusammen. . . .

Chr. Pander.

INTRODUCTION

PROBABLY the single set of facts that biologists who specialize in other branches of their science than embryology carry away in their store of general information is that describing the histological accomplishments of the germ-layers. The embryologists themselves as pedagogues are probably more dogmatic concerning these facts than concerning any other [the recent edition of the Brachet (1935) textbook is a welcome exception]. The fixed and simple concept as expressed in the germ-layer doctrine is easy to remember and accordingly has been gratefully retained for its usefulness as a rule of thumb.

Time and time again contradictions have found their way into the specialized literature of embryology but they have only rarely penetrated into general consciousness. Since the recent work in embryology has had important bearings on the problem, it seems well to review the field once more. The historical approach to the problem has been chosen simply because it is so interesting to trace through the dogged attempt of the human mind to cling to a fixed idea.

EARLY HISTORY

Up to the middle of the eighteenth century, the existence of the process of development was recognized, but its constituent mechanisms were quite unknown. Aristotle, Fabricius, Harvey and many others less illustrious had seen embryos or foetuses and had even watched them develop; they had seen in them the forerunners of adult structures, and had noted the appearance of some of these. How the structures were formed—what their source and what their material—was a question unaskable for many reasons.

In the earlier days of embryology, before the Renaissance, unquestioning belief in a rigidly Aristotelian philosophy limited the explanation of all biological processes, development included, to the basis of a concoction of four humours. Even after the Renaissance, when this explanation had been abandoned in anatomy, it sufficed for embryology because no one could detect, with unaided eye, those developmental processes whose very existence defied suspicion until the invention of the microscope.

For some reason embryologists delayed using this instrument until a century after its introduction, and then, ironically enough, the results of its first employment denied the process of development. Malpighi, in perhaps the most famous error of biology, thought that he discovered the principal adult organs present in the unincubated egg. It was in the refutation of this error, that the possibility that there might be such a thing as a germ-layer was called into existence. Caspar Friedrich Wolff (1758; 1812) looked at the unincubated chick blastoderm and found that the organ rudiments were not yet present in it. He further found that later the gut and probably also the nervous system were formed by a process of folding of a layer of the stuff of which the blastoderm is composed.

Wolff, however, simply saw that the adult organs were not necessarily preformed in the unincubated blastoderm, but that some of them were formed later from layers of the blastoderm. It was Pander, however, student of Döllinger, who really elucidated what these layers were.

FIRST DESCRIPTION OF THE LAYERS

Christian Pander, in his two papers published in Würzburg in 1817, first described the trilaminar structure of the

incubated chick blastoderm. [It was Pander who originally coined the word "blastoderm": "Because the embryo chooses this as its seat and its domicile, contributing much to its configuration out of its own substance, therefore in the future we shall call it *blastoderm*" (1817b, p. 21).] His own description of the three layers (1817a, pp. 5, 11-12) is better translated than paraphrased:

At the twelfth hour the blastoderm consists of two entirely separate layers, an inner one, thicker, granular and opaque, and an outer one, thinner, smooth and transparent. The latter, because of its development and for the sake of greater accuracy of description, we may call the serous layer and the former the mucous layer. . . . There arises between the two layers of the blastoderm a third middle one in which the blood vessels are formed, which we therefore call the vessel-layer; from its origin events of the greatest importance subsequently occur. . . . Actually there begins in each of these three layers a particular metamorphosis, and each one strives to achieve its goal; only each is not yet sufficiently independent by itself to produce that for which it is destined. Each one still needs the help of its companions; and therefore all three, until each has reached a specific level, work mutually together although destined for different ends.

Pander not only recognized the layers once they were formed, but he also realized clearly that one layer was formed at the expense of another. He wrote elsewhere (1817b, pp. 26-27):

What merits most attention is the composition of the blastoderm out of two layers. For before incubation this membrane consists of a single layer, made up of granules which cohere to each other by their own viscosity. As incubation progresses, however, there originates from this another layer, more delicate but firmer in structure, so that at a specific time the blastoderm can be divided by a fairly long maceration into two layers.

ELABORATION OF THE GERM-LAYER CONCEPT

Pander crystallized the germ-layer concept for the chick embryo. His friend and colleague, Karl Ernst von Baer, also a student of Döllinger's, extended it to

encompass all of vertebrate development, thereby laying down the fundamental bases for the study of comparative embryology.

Von Baer (1837, Bd. 2, S. 68) recognized the value of Pander's contribution;

We can speak of an upper and a lower layer; the former we call the skin layer and the latter the mucous layer. The material that lies between the two clings partly to the upper layer and partly to the lower. In this way there gradually develop two inner layers, an upper and a lower. In the lower of the inner layers the granules become clear and dis-



KARL ERNST VON BAER (1792-1876)

only in a way he reorganized it perhaps a trifle too assiduously, since he unjustifiably stretched Pander's three layers to four, breaking up the middle layer into two layers—roughly the equivalent of what we know as somatopleure and splanchnopleure:

solve into vesicles, and finally part of the contents of this layer begins to flow. It becomes a vessel-layer. In the upper the granules become darker; this becomes a flesh- or muscle-layer.

It seems hardly necessary to emphasize that von Baer's most significant contribution, so far as the germ-layers are

concerned, was the recognition of the fact that Pander's discovery for the chick was valid for all the rest of vertebrate development. This has been the basis of embryology from von Baer's time until today.

The question often arises as to what the status of embryology would be without the contribution of von Baer. It might conceivably be little different than it is, because of the insight of another investigator who had the misfortune, from posterity's point of view, to be a contemporary of von Baer. In 1825, several years before the publication of von Baer's treatise, Martin Heinrich Rathke, who had read Pander's paper, applied this author's observations on the germ-layers to the development of an invertebrate, *Astacus*, describing the splitting of the blastoderm into a serous and mucous layer which fit one inside the other "like the coats of an onion" (quoted in E. S. Russell, 1916, p. 208). As a matter of fact Rathke seems to have applied Pander's figurative vocabulary as well as his concept to the invertebrates, since he wrote, without anywhere in his paper referring to Pander: "After the blastoderm has divided into two particular layers, each of these layers proceeds by itself towards its final goal" (translated from Rathke, 1825; pp. 1094-5). So much was stated in the preliminary note. The final paper, which was published in 1829, described the layers more explicitly:

One of them clings closely to the yolk and corresponds to the mucous layer of vertebrates, and is subsequently used for the production of the intestine and of a special yolk-sac. The other, on the other hand, is essentially comparable to the serous layer of the vertebrate, insofar as it . . . forms the body wall of the embryo, from which the different appendages as well as the central part of the central nervous system take their origin. A special and separate vessel-layer is never perceptible . . . [there is] more the idea of it than its actual presence. (Translated from Braem, 1895, S. 495.)

These words show clearly that Rathke saw the implication of Pander's discovery as well as did von Baer. He was able to transfer the analogy even to the Invertebrates. His work was less well known than von Baer's, probably principally because his generalizations were more on the embryological and less on the transcendental side. So far as their actual content is concerned, it would have made as solid a groundwork on which to build the science of embryology as the more celebrated *Scholia* of von Baer.

The significance of von Baer's concept was immediately recognized. In one way, however, it seemed almost a culmination rather than a new point of departure, and for many years the concept was accepted with only slight amplification and refinement.

The refining, very nearly completed by Robert Remak between 1850 and 1855, consisted of a double process: first, the interpretation of the germ-layers as composed of cells which were derived from the single cell of the original egg; second, the essentially correct demonstration that each of the germ-layers has a specific histological future. Remak recognized two primary germ-layers: (1) the upper, or sensory layer, subdivided into medullary plate and its derivatives, and the epidermic plate, and (2) the under layer subdivided into (2a) the trophic layer which gives rise to the alimentary canal and its derivatives, and (2b) the motor-germinative layer which furnishes peripheral nerves, muscle, blood vessels, connective tissue, sex glands, etc. Furthermore, this middle motorgerminative layer is separated into dorsal and ventral somite plates by the pleuroperitoneal cavity, which is the precise equivalent of what we know as the coelome. It is obvious that these are the precise facts of the germ-layer concept as

we recognize them today, with the exception of the one major error concerning the origin of the peripheral nerves.

GERM-LAYERS IN THE VERTEBRATE EMBRYO AND THE ADULT COELENTERATE

Even before Remak had published his book, one investigator was beginning to realize that the two so-called primary germ-layers formed as fundamental a part in the architecture of the adult coelenterate as in the molding of the vertebrate embryo, and he laid the foundation of what was subsequently to become the whole superstructure of phylogenetic and ontogenetic studies so extravagantly elaborated by the adherents of the evolution concept.

Huxley is credited with this discovery. He wrote, in a matter-of-fact manner, in a short paper "On the Anatomy and Affinities of the Family of the Medusae" (1849, pp. 414, 425):

I would lay particular stress upon the composition of this (stomach) and other organs of the Medusae out of *two distinct membranes*, as I believe that this is one of the essential peculiarities of their structure, and that a knowledge of the fact is of great importance in investigating their homologies. I will call these two membranes as such, and independent of any modification into particular organs, 'foundation membranes'. . . . A complete identity of structure connects the 'foundation membranes' of the Medusae with the corresponding organs in the rest of the series; and it is curious to remark, that throughout the outer and the inner membranes appear to bear the same physiological relation to one another as do the serous and the mucous layer of the germ; the outer becoming developed into the muscular system and giving rise to the organs of offense and defense; the inner, on the other hand, appearing to be more closely subservient to the purposes of nutrition and generation.

In a way, it is almost surprising that this discovery had not been made earlier, in view of the fact that Rathke had so early noted that Invertebrates as well as Vertebrates were bilaminar in early development. Also, Cuvier, as Huxley knew,

had remarked on the bilaminar structure of the Coelenterates. In speaking of the Tubularians, Cuvier wrote (1846, p. 557):

Here the polyps do not form simple aggregations in which the individuals are distinct: but they are intimately united in such a way that they compose a more or less complicated individual which we call a compound polyp.

Whatever way the compound polyp is composed, the alimentary or digestive cavity of each polyp opens into a common nutritive tube, into which flows, or is secreted, the nutrient fluid produced by the digestive processes of each polyp.

The walls of the nutritive tube are formed by a double membrane, always intimately fused in this part of the compound polyp; the external corresponds to the skin; the internal is a continuation of the digestive portion of the alimentary cavity (of the individual polyps).

The former, in the compound polyp, secretes from its external surface a tube or sheath, thin like parchment, or horny in nature. . . .

As a matter of fact, however, the investigator who came closest to anticipating Huxley's brilliant generalization was none other than von Baer himself. Von Baer (1837, Bd. 2, S. 67) early compared the primary germ-layers with the walls of the coelenterate, in the following statement:

Yet originally there are not two distinct or even separable layers, it is rather the two surfaces of the embryo which show this difference, just as polyps show the same contrast between their internal digestive and external surface. In between the two layers there is in our embryo as in the polyp an indifferant mass.

The primary germ-layers of the Coelenterates were given their definitive names shortly after the publication of Huxley's paper. In a paper "On the Anatomy and Physiology of *Cordylophora*," Allman wrote in 1853 (p. 368): "All the hydroid zoophytes can be proved to consist essentially of two distinct membranes; to the external of these membranes I shall give the name of ectoderm, and to the internal that of endoderm."

In spite of its importance, the implications of Huxley's brilliant observation remained unnoticed for almost twenty years. Haeckel's *Generelle Morphologie*, for instance, published in 1866, makes no mention of the germ-layers. The dearth of progress is perhaps nowhere better shown than by a study of Huxley's own *Introduction to the Classification of Animals*, published in 1869, exactly 20 years after his first statement concerning the Medusae. In this book, the only statements concerning the germ-layers are: (1) that the Hydrozoa are separated into two layers of tissue, the ectoderm and the endoderm, (2) that the Actinozoa are likewise constructed of two membranes, ectoderm and endoderm, (3) that the author can confirm Remak's statement that the brain and spinal cord of Vertebrates are a result of the modification of the serous layer of the germ, and (4) that the serous layer of the germ helps to form the amnion in the chick embryo while the allantois is formed from neither mucous nor serous layer but from the intermediate stratum. In no case here does he mention any relationship between coelenterate ectoderm and endoderm on the one hand and embryonic serous and mucous layers on the other. In other words, although Huxley had appreciated the fundamental relationship between the body-layers of Invertebrates and the embryonic layers of Vertebrates, yet twenty years later he and all other investigators were still waiting to utilize the generalization in any way, even for pedagogic reasons.

Even at this early date, before the word mesoderm had even been coined, and before the obvious generalization had been made, the germ-layer concept became subject to distortion. In 1865 William His formulated his "archiblast-parablast" theory. This theory, based on a study of the extremely specialized teleostean

development, claimed that the archiblast, composed of the three classical germ-layers, gives rise to all the embryo except the blood vessels and connective tissue which are furnished by the parablast. His's theory bore little lasting effect on the development of embryology, and fortunately was ultimately abandoned even by its author. But it gives perhaps the first example of the way in which the germ-layer theory has been distorted in the course of its development.

EVOLUTIONARY SIGNIFICANCE OF THE GERM LAYERS

In the same years when Huxley was issuing lectures on comparative anatomy that included the words ectoderm and endoderm only in discussion of the Coelenterates, and when His was worrying about the archiblast and parablast, a Russian investigator was making the observations that were most instrumental—partly because of their own inherent worth and brilliance, partly because of the fortunate time at which they were published—in effecting the bond between embryology and anatomy, and between the study of ontogeny and phylogeny.

Alexander Kowalewski, in the years 1867-71, found that all the invertebrate embryos he studied, and these were of many types, were formed of the same primary layers as the vertebrate embryos, and, furthermore, that in all of them alike the layers arise in the same fashion, the inner layer being produced from the outer by a process of invagination. Kowalewski's words can speak for himself more convincingly than we can speak for him (1867a, p. 3):

The first change in the embryo [*Psolinus*, a holothurian] consists of an insignificant invagination which becomes visible at one pole of the egg, and whereby the whole embryo takes on a somewhat conical form. The invagination progresses gradu-

ally farther and after a few hours forms a deep sack. . . . A similar division of the cells of the embryo into two layers, an outer and a central one, I have also observed in many other animals, and especially clearly in the eggs of *Phoronis*.

Nineteen days later, when he presented his paper on "*Amphioxus*" (1867b, pp. 3, 5), the generalization had broadened considerably:

The embryo now consists of two sheets or germ-layers, the outer and the inner; we can therefore compare it with the embryonic anlage of the bird, mammal and turtle-egg, when these still consist of two layers. If we compare figure 15 of Reichert's paper on the development of the guinea-pig with our figures 8 and 9, the similarity between these two forms of development immediately strikes us. . . . The embryo quite agrees, even in the most insignificant details, with the embryo of the corresponding stages of *Phoronis*, of *Limnaeus*, of *Asteracanthion berylinus* Ag., of *Ophiura* and of *Echinus*, according to my own still unpublished observations; and if we leave the cilia out of consideration, our larva agrees also with the corresponding stage of *Sagitta*, of the Ascidians (*As. intestinalis* and *Phalusia mammillata*); if we consider that the segmentation cavity is filled with yolk, it resembles also the larva of *Eschscholzia*, of *Cestum* and of *Sepiola*. In all of the embryos mentioned here the formation of the two laminae or layers proceeds in exactly the same way. . . . Thus the first formation of the embryo would be quite in agreement for all these different animals; only in the further changes do we see appear the differences which characterize the individual type.

And in 1869 (p. 29), he wrote in a paper on worms and arthropods:

Now if we compare the development of the worms we have described with that of other animals, the analogy of the germ-layers of the worms with those of the Vertebrates, even in the details, astonishes us. The same two primitive layers which play the leading rôles in the development of the worm appear also in the Vertebrates; as in the one group so in the other the middle layer appears only later. The destinies of the layers and of the organ anlagen are in very great agreement even down to the individual processes.

Rathke's comparison of the embryonic germ-layers of Vertebrates and Invertebrates remained buried. Huxley's recog-

nition of the relationship of the germ-layers in the adult coelenterate and the embryonic vertebrate, so strangely anticipated by von Baer, scarcely received comment for two decades. But the researches of Kowalewski bore immediate fruit. By 1870 the scientific world was flaming with the debate on evolution that was kindled by the publication of Darwin's *Origin of Species*. The publication of Kowalewski's observations on the universality of the germ-layers and on their comparable origin in a multitude of forms made it possible to consider the evolution of the individual and the evolution of the race in the same light. The decade of the 1870's saw embryology adduced as a complete confirmation of the evolution-hypothesis, and the evolution of the race as an explanation *sine qua non* of the course of evolution or development of the individual.

The first significant attempt to relate phylogeny with ontogeny was that of Kleinenberg, who published in 1872 his monograph on the histology and development of *Hydra*, a paper dedicated, by the way, to Ernst Haeckel. In this the author found the coelenterate the perfect organism to represent the transition form from coelenterate to vertebrate embryo, and to represent the fundamental type on which all other forms are patterned and from which they are necessarily derived:

The low position of the Coelenterates in the system is perfectly understandable from their developmental history. Their type is determined by their maintenance of the fundamental spatial relationship of the germ-layers, and of their different layers in turn, to each other and to the external world. . . . The resultant great simplicity and uniformity of the whole body structure distinguishes the Coelenterates from all other animal groups: in the latter the definitive body arises through far-reaching histological segregations, but principally through manifold transformations and interminglings of the germ-layers,

with the result that these are scarcely recognizable at all in the completed organs, and only in vague outlines in the body as a whole. But if we follow the developmental history of these complicated organizations backwards, we arrive finally, in the Vertebrates and probably in all animal groups, to forms which correspond essentially to those of the

type of the coelenterate is passed through as a developmental stage by all higher animals. The simple type of the coelenterate is the common ground form to which all the infinitely rich and manifold configurations of the animal body can be directly or indirectly referred. (Kleinenberg, 1872, pp. 87-88.)



ERNST HEINRICH HAECKEL (1834-1919) (Photo by Tokuzo Kimura)

Coelenterates. Now since these forms are necessary, but transitory, developmental stages upon which the specific type is built, while on the other hand among the Coelenterates the same forms, maintained unchanged, portray the type, so the conclusion is apparent that not only the developmental processes in all animals are identical up to a certain stage, but that even in individual development the transition of one type into another occurs, since the constant

In 1869 the terms ectoderm and endoderm had not yet been applied to describe the germ-layers of the embryo: in 1872 the terms were being used as they are now by Haeckel in Germany and in 1873 by Lankester in England. The term mesoderm was introduced by Huxley in 1871

(pp. 10-11 of the 1872 edition) in his *Manual of Anatomy*, and it was used by Haeckel (1872) in his monograph *Die Kalkschwämme*. Lankester's paper, published in May 1873, represents, according to its author, "part of a course of lectures commenced in the University Museum, Oxford, during Michaelmas term 1872." Haeckel's *Die Kalkschwämme* appeared in 1872 after Lankester's paper was drawn up but before it was published; whether he adopted Haeckel's terminology, or whether Lankester adopted his, or whether both independently used the same terminology, is not apparent. In 1873 Balfour and Lankester both were using the terms epiblast, mesoblast and hypoblast in place of the other terms. The history of terminology may be a futile study, but in the present case it is interesting since the men we have mentioned as changing the use of words simultaneously deflected the course of thought.

Lankester published in 1873 the preliminary and in 1877 the final communication in which he created a classification of animals based on their constitution into layers: All animals are homoblastic, diploblastic or triploblastic; the triploblastic forms are derived from the diploblastic through the Vermes; the planula, or the larva of the coelenterate, is the parent, phylogenetically speaking, of all diploblastic and triploblastic forms.

Haeckel (1872), in Germany, published simultaneously a similar theory destined to become of greater influence than Lankester's because of Haeckel's genius of expression. Haeckel's concept, in a way, was influenced heavily by the English school, partly because of Haeckel's blind acceptance of the evolution-doctrine and partly because of his deep personal affection for Huxley. The parent of all forms, in Haeckel's theory, is a two-layered sac

similar to the bilaminar stage of all embryos described so skilfully by Kowalewski and known to us by Haeckel's term "gastrula." Haeckel wrote in 1872 (Bd. 1, S. 466-467) in the general part of his monograph on the Calcispongiae:

In all of these representatives of the most varied animal groups the gastrula has exactly the same structure. In each case its simple monaxial oval body encloses a simple central cavity (gastral cavity) which opens through a mouth at one pole; in each case the thin wall of the cavity consists of two cell-layers, an inner layer of larger darker cells (entoderm, gastral layer, inner, trophic or vegetative germ-layer) and an outer layer of smaller generally ciliated lighter cells (exoderm, dermal layer, outer, sensory or animal germ-layer). I conclude from this identity of the gastrula in representatives of the most diversified animal groups, from the Sponges to the Vertebrates, according to the fundamental biogenetic law, that the animal phyla have a common descent from a single unknown stock form, *gastraea*, which is constructed essentially like the gastrula.

According to this theory, the gastrula, Kowalewski's bilaminar sac, produces all embryos; a similar *Urmutter* is therefore the necessary progenitor of all multicellular forms. Finally, the course of evolution of the embryo is step by step explained and *caused* by the evolution of the race to which the developing individual belongs. The development of the gill-slits in a mammalian embryo, to take a familiar instance, would be caused according to Haeckel necessarily and solely by the fact that in the course of evolution the ancestor of the mammal possessed gill-slits. One wonders how the promulgator of such a distorted doctrine of cause and effect could have been championed by the same Huxley who wrote: "Fact I know and Law I know: but what is this Necessity save an empty Shadow of my own mind's throwing?"

Haeckel was probably the transcendentalist par excellence of all biology. Equipped naturally with those rarely combined virtues, an aesthetic apprecia-

tion of a high degree and a passion for methodical terminology and organization, he produced in the gastraea theory a scheme of ideas as intricate and symmetrical as the figures of Radiolarians which he loved to portray with his pen. The most perfect example imaginable of fitting the facts to the theory, a beautiful intellectual feat, totally devoid of scientific value, his gastraea theory was the culmination of the early work on the germ-layers. Some of his contemporaries realized that phylogeny could not explain away ontogeny, and His (1874), for instance, vainly suggested and even attempted a study of the mechanical causes of development. But the beautiful unity of Haeckel's scheme was too seductive. Huxley and the English embryologists spent their days apotheosizing its author and looking at embryos only for the purpose of fitting the facts of ontogeny into the ideal of phylogeny.

Kleinenberg (1886, p. 2), who had nominated *Hydra* and the Coelenterates for the throne usurped by Haeckel's "gastraea," gave a succinct and vivid critique of the gastraea theory in his paper on the development of *Lopadorhynchus* which this time bore no dedication:

The good in it (the gastraea theory) belongs to Huxley; what Haeckel has done to it is false, or perverted, or meaningless. It is false to trace all kinds of endoderm-formation back to the invagination of the blastoderm. It is perverted to substitute a problematical gastraea in the place of the coelenterate type. The value of Huxley's idea lay for the greater part in that it brought the early developmental stages of the higher Metazoa into immediate alliance with the completed forms of countless living Coelenterates. These latter are very diverse among themselves and still remain Coelenterates; that greater differences must exist between an adult coral and the larval form of an annelid is understandable, and will hinder no one from seeing the essential similarity of both organizations. In any case it was unnecessary to leave the Present and to descend into the Laurentian night to call forth as lean an animal-

spectre as the gastraea. It is, incidentally, obvious that the gastraea is not able by itself to create the slightest hypothetical conception of the unknown origin of the Coelenterates, because the gastraea is nothing more than the coelenterate type schematized. Courageous hypotheses—daring conclusions—these almost always are of service to Science. But Schemata injure her if they bring existing knowledge into an empty and warped pattern, and claim thereby to give deeper understanding. Unfortunately the gastraea was not fertile, but it was strongly infectious; it has propagated itself as Neuraea, Nephridaea, etc. and is guilty of all the Original-animals, the Trochosphaera, the Trochophora, the Original-insect, and I know not what besides.

Meaningless is the homologising of the gut-cavity of the higher Metazoa with the endoderm-cavity of the gastraea; a hole is a hole anywhere in the world. If once the equivalence of the walls is established, people will not need to worry their heads about the empty spaces inside.

EARLY OBJECTIONS TO THE GERM-LAYER DOCTRINE

The first voices were raised against the germ-layer doctrine during the 1870's. Since those of Kölliker and the Hertwigs were loudest, and since the precepts of these authors epitomized those of their contemporaries, they may best be chosen as an example of the mode of reasoning of the opponents of the doctrine.

Kölliker (1879, '84, '89) questioned the validity of the doctrine principally from the histologist's point of view. While some of his reasoning now seems quaint, and some has since been invalidated by modification of the doctrine, some is still cogent. He claimed that the outer layer gives rise to many diverse types of cells—to epithelium, nervous cells, neuroglia, the pigment epithelium in the eye, etc. He added, however, basing his statement on his own observations and those of Leydig and Ranvier, that the outer germ-layer could give rise to smooth musculature in the case of the sweat-glands.

So far as the middle germ-layer is concerned, Kölliker claimed that this also

gave rise to too many diversified types of cell to have any meaning as a single entity. He emphasized that chorda is in some cases derived from the mesoderm and in others from endoderm—a fact without significance to us, who know

mesoderm, since the blastema from which all the hindmost structures are formed is predominantly mesodermal in origin.

So far as the endoderm is concerned, he erroneously claims that in *Amphioxus* it goes so far as to form somites and muscle



RUDOLF ALBERT VON KÖLLIKER (1817-1905)

that chorda and mesoderm each stem from a different group of cells, but which was at one time one of the most disputed facts of the whole doctrine. He adds further that so far as the hindmost part of the embryo is concerned, in a certain sense even the nervous system is formed from

and connective tissue, and that in many lower forms it produces chorda.

When Kölliker turns to a study of the Coelenterates, he claims, on the basis of his own work and that of other authors, that muscles and germ-cells, and in some cases even nervous tissue, are formed

sometimes from ectoderm and sometimes from endoderm. His evidence so far as the germ-cells are concerned is invalidated by the later discovery that these are derived from neither germ-layer but from cells which were probably segregated

originally all the cells of the embryo, as they are produced by cleavage, are equivalent, so we may assert the proposition that all three germ-layers possess the potency and the capacity also for transformation into all tissues, but because of their specific morphological configurations they cannot everywhere manifest this power. (1879, S. 389.)



OSCAR HERTWIG (1849-1922)

(Photo by Tokuzo Kimura)

during early development. However, his conclusions concerning the muscle are still valid. He concluded:

In consequence of all these considerations the conviction is irresistably striking that the significance of the germ-layers is not histo-physiological but morphological. If we proceed from the fact that

While many of the facts on which Kölliker based his claims have been disputed, many of them still hold true, and as a matter of fact his reasoning does not suffer even when the evidence has been invalidated. Many of Kölliker's conclusions were admittedly based

on evidence derived from the Hertwigs' studies on the Coelenterates. In 1878 the Hertwigs raised their first questions about the application of the germ-layer theory in a small monograph dealing with the histology of the Medusae. Inquiring, as had Kleinenberg, into the relationships of ectoderm and endoderm to mesoderm, they concluded that what they consider mesoderm in the Medusae is simply a product of the histological differentiation of ectoderm and endoderm. In their monograph on the Actinians, published a year later (1879) as the first of their definitive "Studies on the Germ-layer Theory," they continue their discussion, questioning the precise relationship of the two layers of the Coelenterates to the three of higher forms. On evidence that in some coelenterate groups germ-cells or musculature are derived from ectoderm and in others from endoderm, they conclude that "within particular animal groups the germ-layers have differentiated organologically inequivalently" (1879, p. 205). Furthermore they extend their generalizations, supporting themselves by evidence from other authors similar to that of Kölliker's outlined above, to include the other animal groups as well as the Coelenterates:

The germ-layers are neither organological nor histological entities. It is not possible, if one knows the origin of an organ in one animal group, to carry over the result to all other animal groups. . . . Just as the capacity for transformation of individual cells, so is that of a germ-layer highly manifold, and it can express itself in the most different ways in the production of organs and tissues. (1879, pp. 216, 217.)

Here the Hertwigs have put their fingers on the whole solution of the germ-layer problem; but unfortunately they were not satisfied to stop here with a constructive contribution. Instead they chose to supplant the gastraea theory, which they had destroyed, with another

theory which was not only unnecessary but even more far-fetched, if possible, than its predecessor.

This they achieved by continuing the discussion of the difficulty arising from the attempts to homologize similar tissues developing from different germ-layers in diploblastic and triploblastic forms, and to find any uniformity whatsoever in the mesoderm which originates and develops so widely divergently in the various animal forms. Instead of following out their original suggestion that the germ-layers have wider capacities for differentiation than is usually recognized, they preferred to force the widely differing behaviour of mesoderm in different forms into a common pattern by their coelome theory (1881). According to this, the mesoderm (the mesoderm is in this paper first subdivided into mesenchyme and mesoblast; the latter term had been in use to describe the whole middle layer for many years) necessarily always arises from the endoderm, enclosing within its two layers part of the alimentary cavity as the "coelome" (Haeckel's name for the pleuro-peritoneal cavity of Remak). According to the Hertwigs (1881, p. 122):

Ectoblast and entoblast are the primary germ-layers which originate by invagination of the blastula; they are therefore always the first formed and they can be referred back to a simple stem-form, the gastraea. . . . Parietal and visceral mesoblast, or the middle germ-layers, always originate later, and arise through a pouching or folding of the entoblast; . . . They bound a new cavity, the enterocoel, which may be considered a pinched-off diverticulum of the archenteron. As the two-layered animals are derivable from the gastraea, so are the four-layered from a coelome-form.

The whole theory, as an explanation of development, can probably never be better described than it has been by Braem (1895, p. 468) who wrote: "So the coelome theory, with all of its conse-

quence, presents one of the most glaring inconsequences to which the morphological conception of the germ-layers can lead."

This nice statement of Braem's formed part of a series of papers published in

solution of the problem that he could offer was that the germ-layer theory was based purely on topography, while the homologies, or rather the analogies, of the layers could be comprehended only on a physiological basis.



RICHARD HERTWIG (1850-1937)

(Photo by Tokuro Kimura)

1895 and entitled "What is a Germ-layer?", in which the author scrutinized the whole germ-layer doctrine from many angles. He raised the same doubts as to its validity as had the other investigators whom we have quoted; the only

THE GERM-LAYERS IN REGENERATION AND BUDDING

To be sure, this particular period saw the beginnings of the first attempt since His's to deal with the problem from a physiological point of view, or at least

from an experimental rather than a descriptive point of view. Perhaps the word *experimental* is dangerously used in this connection, since in one of the first important cases the experiment was performed by nature and simply observed

lus; in the bud they are each derived not from the outer but from the inner layer. Hjort concluded that the layers of the bud are not germ-layers in the ordinary sense, but were composed of still indifferent material.



WILHELM HIS (1831-1904)

and interpreted by the investigator. Hjort (1894a, b), in his study of bud-formation in the Ascidians, made the accurate and cogent observation that in *Botryllus* organs are not formed from the same germ-layers in egg-development and in budding. In development from the egg, for instance, the atrial chamber and the ganglion are each formed from the ectoderm in *Botryl-*

The import of this discovery was at once appreciated as jeopardizing the validity of the doctrine. Heider (1897), in a paper that like Braem's was entitled with a rhetorical question never answered, "Is the Germ-layer Doctrine Shattered?", insisted that findings like those of Hjort were irrelevant so far as the germ-layer doctrine in embryology was concerned.

The doctrine, according to Heider, still holds for embryology, where it belongs, whether or not it holds true for the cases of budding and regeneration which are problems separate from those of embryology.

A more convincing argument, however, had been promulgated the year before by E. B. Wilson (1896) in a brilliant lecture at Woods Hole on "The Embryological Criterion of Homology." Wilson maintained that the conditions in bud-formation and regeneration were vitally significant for a comprehension of the processes in the embryo. He wrote (pp. 112-113):

It may be urged that in regeneration and agamogenesis development is condensed and abbreviated so as no longer to repeat the phyletic development, and this is no doubt true. This explanation contains, however, a fatal admission; for if secondary modification may go so far as completely to destroy the typical relationships between the germ-layers and the parts of the adult, then those relationships are not of an essential or necessary character, and we cannot assume that the germ-layers have any *fixed* morphological value, even in the gastrula.

FIRST EXPERIMENTAL ATTACK ON THE PROBLEM

While philosophically speaking it may have seemed difficult to their contemporaries to choose between the interpretations of Heider and Wilson, even before their papers had been published the first experiment had been performed along the lines of the later ones which were finally to throw the balance to the side of Wilson. During 1892-93 Herbst subjected echinoderm eggs to treatment with a large variety of salts. He found that lithium had a specific effect on their development, namely the production of exogastrulae and entogastrulae in which the amount of endoderm in the embryo is greatly increased at the expense of the ectoderm.

In figures 11, 6, 12-14, there thus occurs a gradual increase of endoderm, and hand in hand with it a

successive reduction of ectoderm. In figure 13 the latter is present only as the small button labelled *ga*, and in figure 14 it is no longer present at all; here the whole blastula wall has been transformed to endoderm (1893, p. 144).

Herbst appreciated the implication of his results; not so did his contemporaries who did not wish to. Heider, for instance, in the paper referred to above, mentioned the lithium-embryos only as a possible explanation of how in the production of endoderm in Coelenterates the processes of multipolar migration and delamination might have been derived from polar migration.

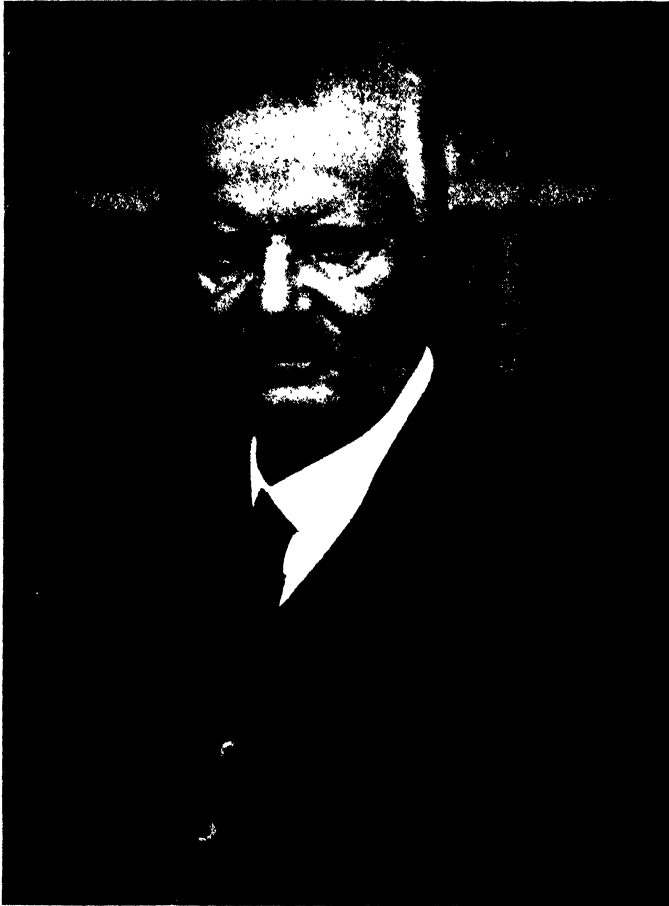
THE PATHOLOGISTS AND THE GERM-LAYER DOCTRINE

Indeed the main body of embryologists (cf. Sedgwick, 1910) went their way, promulgating the germ-layer doctrine and attempting always to support and strengthen it. One other group of scientific investigators discussed the problem avidly: the pathologists, who were seeking panaceas to solve the atypical growth problem. Some of them, perhaps most notably Marchand (1899-1900), unsuccessfully sought the aid of the germ-layer doctrine. They contributed more to the embryologists, however, than they received from them, since they could furnish evidence both pro and con. Not the most influential, but perhaps one of the most interesting results of the cooperation between pathology and embryology, was the prophecy of the experiment, and its results, which have been most instrumental in abolishing the notion of the fixity of the layers. C. S. Minot in a paper on the embryological basis of pathology wrote, in 1901 (p. 485): "It seems quite probable to me that the cells of the germ-layers are at first quite indifferent, so that if it were possible to graft a young mesodermal cell on to the

ectoderm or endoderm, it would become a true ectodermal or endodermal cell, as the case may be." A similar experiment, performed by Mangold a quarter of a century later, has been considered one of the crucial experiments in the demonstration of the non-specificity of the germ-layers.

discuss in this connection the results of the work on vertebrate embryos.

The interpretation of the experiments on the germ-layers of the Vertebrates was facilitated, in fact made possible, by the background work of Vogt (1925) who charted out on the amphibian blastula,



HANS SPEMANN (1869-)

MODERN EXPERIMENTAL WORK

1. *Vertebrates*

The turn of the century saw the embryologists change their method of attack from observation to actual operative manipulation. The capacity of the germ-layers for differentiation could now be tested as well as inferred. We may first

by means of local vital staining, the precise locations of the areas later to become chorda, mesoderm, gut, epidermis and nervous system. Once the position of these cell-groups before gastrulation was known, their behavior in unusual positions, or in isolation, could be appreciated.

Perhaps the most far-reaching results on

the activity of the germ-layers, established experimentally, were those which demonstrated the influence of the lower invaginated layers of the amphibian embryo on the differentiation of the overlying ectoderm. Spemann had, in 1918, as is well known, noted the power of transplanted dorsal lip of the blastopore of the amphibian gastrula to induce the formation of a new embryo from presumptive epidermis; in 1924, in an investigation carried out with the collaboration of Hilde Mangold, similar experiments were performed using hosts and donors of different species whose tissues were sharply distinguishable from each other in sectioned material. From the results of this experiment it became apparent that the medullary plate in the induced embryo was formed by the host, while the underlying gut, chorda and mesoderm were furnished in part by the grafted dorsal lip. This result, and others of Spemann's (1918) from experiments in which presumptive epidermis was exchanged with presumptive medullary plate, or in which areas of medullary plate and mesoderm of the neurula were rotated through 180° (1912), suggested that the lower layers were somehow responsible for the differentiation of the upper. This was crucially and definitely demonstrated by Marx, who found, in 1925, that a piece of already invaginated archenteron roof, implanted into the blastocoele cavity, induced the formation of medullary plate from presumptive epidermis. Subsequently Bautzmann (1926, '28) was able to show by similar transplantation experiments that both presumptive chorda and presumptive mesoderm display the power of inducing the overlying epidermis to differentiate medullary plate.

All of these transplantation experiments suggest immediately the interpretation that the underlying layers, particularly

mesoderm and chorda, as the inducing system (to use a term later introduced), are somehow inherently different in their capacities than the responding system of the overlying ectoderm. This interpretation has been in one way borne out by results of explantation experiments, and by the production of amphibian exogastrulae. When amphibian embryos, especially axolotls, are treated with appropriate salt solutions, the mesoderm, endoderm and chorda roll outwards instead of inwards, with the result that the ectoderm remains simply an empty bag. In such exogastrulae, the mesoderm and endoderm and chorda self-differentiate to form somites, gut and notochord histologically quite typical of the normal embryo; the ectoderm, on the other hand, deprived of the proximity of these layers, forms only epidermis and never nervous system (Holtfreter, 1933).

Similarly in explantation experiments, in which isolated parts of the amphibian gastrula are cultured in salt solutions, as shown by Holtfreter's (1938 a, b) masterly work, isolated ectoderm fails to differentiate nervous tissue; it forms only epidermis when deprived of influence of cells of the other layers. The presumptive endoderm, whose rôle has been least clearly analyzed in the transplantation experiments, when isolated in salt solution self-differentiates only endodermal structures.

Cells of the presumptive chorda and mesoderm regions, in contrast to those of the other two germ-layers, readily overstep the classical bounds of the germ-layers, and when isolated in salt-solution can self-differentiate, or induce from their own cells, according to interpretation, medullary plate and epidermis on the one hand, and gut on the other, in addition to forming the usual mesodermal structures.

If the experiments are carried out, however, by placing the isolates *in vivo* rather than *in vitro*, the ectoderm and endoderm can accomplish far more than in salt solution. This has been demonstrated by Kusche (1929) and Bautzmann (1929), who placed the tissues into the empty orbital cavity of older larvae, and Holtfreter (1929) who implanted them into the abdominal cavity of amphibian larvae. In these cases, presumptive ectoderm formed not only medullary tube, but also notochord and muscle, and presumptive endoderm was able to differentiate notochord. Here where the cells were subjected to influences of highly complex organic nature, even ectoderm and endoderm were able to differentiate structures normally formed by the other germ-layers. The nature of these external influences and of their action is unknown. But their effect is sufficient to demonstrate that the differentiating cells themselves have a wider capacity for diversification than the other experiments had suggested.

These are by no means the only clear-cut experiments demonstrating the variety of potencies expressible by the cells of the amphibian gastrula. Mangold had in 1923 performed the experiment postulated twenty years before by Minot and thus dealt the germ-layer doctrine one of its most mortal blows. He found that presumptive ectoderm formed somites, chorda, pronephros, etc. when grafted into appropriate regions. Furthermore, Bruns (1935) showed that when large defects were made in the presumptive ectoderm of amphibian gastrulae, the medullary plate could be formed from presumptive mesoderm. Lopaschov (1935) also showed that when several explants of presumptive mesoderm fused they frequently produced medullary plate. Lehmann (1937) has shown that lithium has a specific meso-

dermizing effect on presumptive notochord material in the amphibian gastrula.

Similar demonstrations have been made on other forms than amphibians. Hunt (1937 a and b) has shown for the chick that after removal of the presumptive endoderm the mesoderm can form gut, and indeed that even normally it makes a large contribution to the formation of this structure. It also has been shown for the fishes (Oppenheimer, 1938) that presumptive mesoderm can differentiate nervous structures under certain conditions.

The perfectly valid objection can be raised that in all the cases enumerated the cells whose accomplishments are being studied have been observed acting under highly abnormal conditions, and though it does not necessarily invalidate the results of the experiments, this is to a large extent true. There are, however, some striking cases in vertebrate development where, even in the intact embryo, cells of one germ-layer form structures usually contributed by the others. One of these, touched on by Kölliker (1884), is in tail-formation in the Vertebrates. Kölliker had postulated that all the structures in the tail of a vertebrate embryo were formed from a blastema that was primarily mesodermal in origin. Such is not precisely the case in the amphibian embryo, but the actual conditions as they are support Kölliker's conclusion very strongly. The notochord of the amphibian embryo's tail is formed as a prolongation of that of the trunk. The tail somites, however, as demonstrated conclusively by the vital staining experiments of Bijtel (1931), are formed by the posterior portion of the medullary plate itself. Here is a clear-cut case in normal development where typically mesodermal structures are formed by cells ectodermal in origin.

Another such case is shown by the

behaviour of the cells of the neural crest. The history of the work on this problem has been fully reviewed by Harrison and therefore need only be summarily discussed here. [All references concerning the neural crest cited here may be obtained from Harrison's (1938) paper.] The neural crest, as every one knows, is clearly an ectodermal derivative in the sense of the germ-layer doctrine. However, it was demonstrated even in the last century that it furnished mesenchyme (Kastschenko and Goronowitsch), and, in 1894, it was given, together with the branchial sensory placodes which make a similar contribution, the name of mesectoderm, by von Kupffer. In 1897 Miss Platt showed, on morphological grounds, that the branchial skeleton was derived from mesectoderm. The recent experimental evidence has demonstrated that the neural crest unquestionably forms the Schwann sheath-cells, the spinal ganglia, part of the cranial ganglia, the branchial skeleton, mesenchyme, melanophores and xanthophores, possibly the ganglia of the sympathetic nervous system, and probably the pia-arachnoid membranes.

2. Invertebrates

Such varied accomplishments of the germ-layers are characteristic not only of the vertebrates, but of invertebrates as well. Probably as many single isolated cases could be enumerated for the Invertebrates as have been for the Vertebrates, but here we shall confine our remarks to two groups.

One of the most clear-cut cases imaginable of the transformability of the germ-layers has been presented by Penners (1926, '37a and b, '38) in his beautiful studies of the development of *Tubifex*. The *Tubifex* egg, as described by Penners (1924) exhibits the spiral cleavage characteristic of the annelid egg. It is further

characterized by the presence at its animal and ventral poles of a special "pole-plasm" which passes during cleavage into the cells 2d and 4d which give rise respectively to the ectodermal and mesodermal germ-bands of the embryo. If the pole-plasm is eliminated or divided the cells 2d and 4d and subsequently the germ-bands fail to form or are doubled, as the case may be. Penners (1926) showed that if 2d or 4d were excluded from development, ectodermal or mesodermal germ-bands respectively failed to form; each type of germ-band, however, could differentiate apparently normally in the absence of the other (i.e. when 2d was removed and 4d left intact or vice versa). Later (1937a) he performed similar experiments, allowing the worms to develop to late stages, and the results here were extraordinarily interesting. In the absence of the ectodermal germ-bands, the mesoderm can later form all the organs usually formed by the ectodermal—central nervous system, circular musculature, lateral line, and the ectodermal portion of the seta-sacs. If, however, the source of the mesodermal germ-bands is removed and the ectodermal left intact (Penners, 1937b) the organs normally formed by the mesoderm are not replaced. It is nevertheless extremely interesting and important that in a form characterized by a relatively highly mosaic development the organs formed normally by one germ-layer can be formed by another.

The modern work on the Echinoderms has shown that in this form also the germ-layers have great adaptability. This was first suggested by Herbst's (1892-93) chemical experiments; it has been demonstrated repeatedly in defect- and transplantation experiments. The R nnstr ms (1918-19) showed, for instance, that animal halves of a holothurian egg, containing only presumptive ectoderm, could

differentiate the coelome which is normally formed by mesenchyme, and subsequently Hörstadius (1928) has shown that coelome may be formed in regeneration by ectoderm, endoderm or mesoderm. Recently the chemical and defect- and transplantation experiments have been extended, and they have been amplified and reinterpreted in the light of physiological studies on the developing egg and its parts in such a way that our picture of the developing echinoderm egg is as complete as any we have in embryology.

In the early defect-experiments, Driesch (1891-92, 1892-93, 1900) erroneously supposed all the parts of the developing echinoderm to be totipotent. This problem was clarified by Hörstadius (1928, '35) who showed that isolated animal halves of eggs, which contain only presumptive ectoderm, cannot gastrulate or form endoderm, while isolated vegetal halves can gastrulate and form plutei; sometimes the plutei have an overabundance of endoderm; and sometimes the isolated vegetal halves form exogastrulae with very large guts. The results of these experiments, and of similar ones involving smaller parts of the egg, gained significance with the publication of von Ubisch's (1933) paper which demonstrated on the basis of vital staining experiments the precise normal rôles of the various portions of the egg. The animal half of the egg, consisting at the 32-cell stage of a dorsal group of 8 cells (an^1) and a ventral group of 8 (an^2), forms the ectoderm of the dorsal surface of the pluteus. The vegetal half is divided at the 64-cell stage into a dorsal ring of 8 cells (veg^1) which forms aboral ectoderm, a more ventral ring of 8 cells (veg^2) which forms the endoderm, and at its most ventral pole the micromeres which form the mesenchyme. Driesch (1893) knew that the micromeres formed the mesenchyme, and all the workers

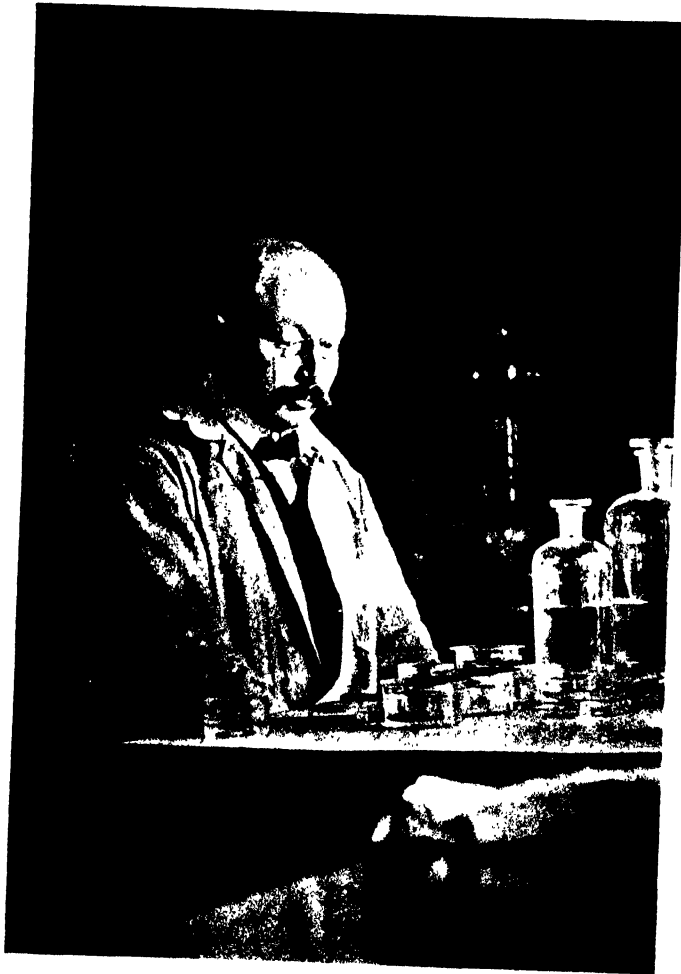
previous to von Ubisch appreciated that the animal pole represented presumptive ectoderm. The main important point demonstrated by von Ubisch was that the upper part of the vegetal half also contained presumptive ectoderm.

The transformability of the germ-layers has been fully demonstrated by Hörstadius (1935) in his ingenious experiments of separating and recombining the cells whose normal behaviour is well known. He has shown, for instance, that when veg^2 , which comprises the presumptive endoderm and normally forms gut, is eliminated from development, a normal pluteus results whose gut is formed by veg^1 which is composed of the presumptive ectoderm for the aboral surface. If both veg^1 and veg^2 are eliminated, again a normal pluteus forms whose gut is made by ectoderm of the animal half of the egg. In both of these cases the micromeres are considered to induce the ectoderm to become endoderm; but no matter what the mechanism, the result is that presumptive ectoderm forms endodermal structures. Similarly, micromeres implanted into the animal pole of whole eggs induce the formation of accessory gut from presumptive ectoderm. Entodermizing of presumptive ectodermal material occurs also when blastomeres are separated and recombined in such a way that the proportion of presumptive ectoderm to presumptive endoderm is far greater than usual; for instance, when a meridional half of an egg is combined with an animal half.

The transformability of the presumptive endodermal cells has also been shown by Hörstadius (1928). An isolated veg^2 group, for instance, is able to form ectoderm, though to be sure such ectoderm is slightly abnormal, as shown by the fact that it forms no stomodaeum nor ciliated band, and the skeleton, whose arrangement

depends on an interaction between ectoderm and mesenchyme, is somewhat abnormal. Driesch (1893) had known that eggs deprived of their micromeres could form normal plutei. Hörstadius demon-

being studied. Herbst (1892, '93) had shown that in whole eggs presumptive ectoderm could be caused to differentiate endoderm by the action of lithium. Von Ubisch (1929) showed that isolated animal



CURT HERBST (1866)

(Photo by Tokuzo Kimura)

strated that in such eggs the secondary mesenchyme, which is derived from veg², is formed earlier than normal and serves to form the skeleton.

Fortunately in the case of the echinoderm egg the physiological basis for the transformability of the germ-layers is

halves, consisting only of presumptive ectoderm, which normally form no endoderm and fail to gastrulate, could accomplish both these tasks after treatment with lithium. Hörstadius (1936) has shown, by varying the length of treatment and by using parts of eggs isolated for varying

lengths of time, that the action of the lithium on the presumptive ectoderm is strikingly similar to that of implanted micromeres.

This work, beautiful in itself, has gained considerably in significance through the work of Lindahl and his co-workers (Lindahl, 1936; Lindahl and Stordal, 1937; Lindahl and Öhman, 1938). Lindahl suggested originally that in the whole egg the animal half, the presumptive ectoderm, exhibits a higher respiratory rate than the vegetal. Similarly, eggs "animalized" by chemical treatment have a higher respiratory rate than isolated vegetal halves. The action of lithium inhibits respiration, so that the presumptive ectoderm which is made to form endoderm simultaneously decreases its respiratory rate. Conversely, the presence of NaSCN or the absence of sulphate ion stimulates respiration and ectodermalizes presumptive endoderm. There are probably two systems of respiration involved at the two poles of the egg which act in a way synergistically, and the system at the animal pole is probably concerned with carbohydrate metabolism.

Lindahl and Holter (1938, unpublished) have been unable to find confirmatory evidence of Lindahl's original statement that the respiratory rate is higher in the animal than in the vegetal portion of the egg. In any case, no matter what the precise nature of the respiratory systems, the transformation of ectoderm to endoderm, and vice versa, has been shown definitely to have a metabolic as well as a morphological basis.

CONCLUSIONS

The only conclusion that can be maintained, as a result of all the experiments that have been enumerated, is that the doctrine of the absolute specificity of the germ-layers as enunciated in the last

century must be abandoned. There are no doubt countless cases where in a specific animal form, the cells of one germ-layer cannot alone perform the functions characteristic of another, as for instance is the case with the ectodermal germ-bands of *Tubifex* (Penners, 1937b). There are however so many contrary accomplishments that even in the classical cases the differentiation of the cells must be based on other factors than their derivation from a specific layer. The nature of such factors probably varies in every instance. In some cases, such as the *Tubifex* egg, the constitution of the cytoplasm before cleavage plays an important rôle. In other cases, as with the echinoderm egg, the special metabolism of parts of the egg is of decisive importance. The precise topographical position of the cells is often significant, as in the case of amphibian development. The interactions of various cells one with another are of vital importance in controlling their differentiation in the vertebrates.

If so many factors other than the origin of the cells from particular germ-layers are of such vital importance, the question arises:—What is the significance of the germ-layers, if any? No matter what the precise factors involved, it seems certain that the precise location of a cell during gastrulation in many forms, or the precise origin of its cytoplasm from the egg in others, is in many cases correlated with the type of its later activity; therefore in a certain sense the germ-layers are of topographic significance, since the cells pass through them in their orderly progression of movements. In a teleological sense, formation of germ-layers seems to be the embryo's method of sorting out its constituent parts. The essential point is, however, that this method is not the only method that the embryo

can call upon to attain a specific end, and here as in many other cases in development the embryo can, when necessary, modify or abandon one method in favor of another. This point, anticipated by Kölliker (1879), as we have already shown, has been well stated in the Brachet textbook (p. 296): "In reality, the germ-layers, like the blastomeres, have an actual potentiality and a total potentiality; the former is what they normally become; the latter what they are capable of forming in addition under diverse natural or experimental influences."

The task of the student of the germ-layers then must become more than an attempt to discern how the embryo sorts

its cells into one layer or another; it must become an elucidation of how the wide potencies of the germ-layers become subject to limitation to their normal accomplishment. Pander, who was first to describe the germ-layers, was fortunate and wise in emphasizing the interactions of the layers with each other. We should do well to emulate him, for only when we can more appreciate the manner and mechanisms of such interactions shall we understand the true significance of the germ-layers themselves.

[The portraits of Karl Ernst von Baer and Rudolf Albert von Kölliker are reproduced from Nordenskiöld's *History of Biology*, 1928, with the permission of the publisher Alfred A. Knopf, New York.]

LIST OF LITERATURE

Papers with comprehensive bibliographies on the germ-layer doctrine are marked with an asterisk.

ALLMAN, G. J. 1853. On the anatomy and physiology of *Cordylophora*: A contribution to our knowledge of Tubularian zoophytes. *Phil. Trans. Roy. Soc. London*, vol. 143, pp. 367-384.

VON BAER, K. E. 1828-37. Ueber Entwicklungsgeschichte der Thiere. Beobachtung und Reflexion. Königsberg.

BALFOUR, F. M. 1873. The development and growth of the layers of the blastoderm. *Quart. J. Micr. Sci.*, vol. 13, pp. 266-276.

BAUTZMANN, H. 1926. Experimentelle Untersuchungen zur Abgrenzung des Organisationszentrums bei *Triton taeniatum*, mit einem Anhang: Ueber Induktion durch Blastulamaterial. *Arch. f. Entw.-mech.*, Bd. 108, S. 283-321.

---. 1928. Experimentelle Untersuchungen über die Induktionsfähigkeit von Chorda und Mesoderm bei *Triton*. *Arch. f. Entw.-mech.*, Bd. 114, S. 177-225.

---. 1929. Ueber bedeutungsferne Selbstdifferenzierung aus Teilstücken des Amphibienkeimes. *Naturwiss.*, Jahrg. 17, S. 818-827.

BIJTEL, J. 1931. Ueber die Entwicklung des Schwanzes bei Amphibien. *Arch. f. Entw.-mech.*, Bd. 125, S. 448-486.

BRACHET, A. 1935. *Traité d'embryologie des vertébrés*. Seconde édition revue et complétée par A. Dalcq et P. Gerard. Paris.

*BRAEM, F. 1895. Was ist ein Keimblatt? *Biol. Centralbl.*, Bd. 15, S. 427-443, 466-476, 491-506.

BRUNS, E. 1931. Experimente über das Regulationsvermögen der Blastula von *Triton taeniatum* und *Bombinator pachypus*. *Arch. f. Entw.-mech.*, Bd. 123, S. 682-718.

CUVIER, G. 1846. *Leçons d'anatomie comparée*. Tome huitième contenant les organes de la génération et des sécrétions, avec une leçon complémentaire des organes de relations; par G. Cuvier et G.-L. Duvernoy. 21ème édition, corrigée et augmentée. Paris.

DRIESCH, H. 1891-92. Entwicklungsmechanische Studien. I. Der Werth der beiden ersten Furchungszellen in der Echinodermenentwicklung. Experimentelle Erzeugung von Theil- und Doppelbildung. II. Ueber die Beziehungen des Lichtes zur ersten Etappe der thierischen Formbildung. *Zeit. wiss. Zool.*, Bd. 53, S. 160-189.

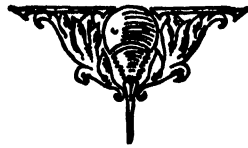
---. 1892-93. Entwicklungsmechanische Studien. III. Die Verminderung des Furchungsmaterials und ihre Folgen (Weiteres über Theilbildungen). IV. Experimentelle Veränderungen des Typus der Furchung und ihre Folgen (Wirkungen von Wärmezufuhr und von Druck). V. Von der Furchung doppelbefruchteter Eier. VI. Ueber einige allgemeine Fragen der theoretischen Morphologie. *Zeit. wiss. Zool.*, Bd. 55, S. 1-62.

---. 1893. Entwicklungsmechanische Studien. VII. Exogastrula und Anenteria (über die Wirkung von Wärmezufuhr auf die Larvenentwicklung der Echiniden). VIII. Ueber Variation der Mikromerenbildung (Wirkung von Ver-

- dünung des Meerwassers). IX. Ueber die Vertretbarkeit der "Anlagen" von Ektoderm und Entoderm. X. Ueber allgemeine entwicklungsmechanische Ergebnisse. *Mitt. zool. Stat. Neapel*, Bd. 11, S. 221-254.
- DRINCER, H. 1900. Die isolierten Blastomeren des Echinidenkeimes. Eine Nachprüfung und Erweiterung früherer Untersuchungen. *Arch. f. Entw.-mech.*, Bd. 10, S. 361-410.
- HAECKEL, E. 1866. *Generelle Morphologie*. Berlin.
- . 1872. Die Kalkschwämme. Eine Monographie. Berlin.
- *HARRISON, R. G. 1938. Die Neuralleiste. *Er-ganzheft. zum Anat. Anz.*, Bd. 85, S. 3-30.
- *HEIDER, K. 1897. Ist die Keimblätterlehre erschüttert? *Schubergs Zool. Centralbl.*, Jahrg. 4, S. 725-737.
- HERBST, C. 1892. Experimentelle Untersuchungen über den Einfluss der veränderten chemischen Zusammensetzung des umgehenden Mediums auf die Entwicklung der Thiere. I. Theil. Versuche an Seeegeln. *Zeit. wiss. Zool.*, Bd. 55, S. 446-518.
- . 1893. Experimentelle Untersuchungen über den Einfluss der veränderten chemischen Zusammensetzung des umgebenden Mediums auf die Entwicklung der Thiere. II. Theil. Weiteres über die morphologische Wirkung der Lithiumsalze und ihre theoretische Bedeutung. *Mitt. Zool. Stat. Neapel*, Bd. 11, S. 136-220.
- HERTWIG, O. 1881. Die Entwicklung des mittleren Keimblattes der Wirbelthiere. *Jena*.
- *—. 1906. "Die Lehre von den Keimblättern." In O. HERTWIG: *Handbuch der vergleichenden und experimentellen Entwicklungslehre der Wirbelthiere*. Bd. 1, Theil 1, S. 699-967. *Jena*.
- , AND R. 1878. Der Organismus der Medusen und seine Stellung zur Keimblättertheorie. *Jena*.
- , AND —. 1879. Studien zur Blättertheorie. Heft I. Die Aktinien anatomisch und histologisch mit besonderer Berücksichtigung des Nervensystems untersucht. *Jena*.
- , AND —. 1880. Studien zur Blättertheorie. Heft II. Die Chaetognäthen. Ihre Anatomie, Systematik und Entwicklungsgeschichte. *Jena*.
- , AND —. 1881. Studien zur Blättertheorie. Heft IV. Die Coelomtheorie. Versuch einer Erklärung des mittleren Keimblattes. *Jena*.
- HERTWIG, R. 1880. Studien zur Blättertheorie. Heft III. Ueber den Bau der Ctenophoren. *Jena*.
- HIN, W. 1865. Die Häute und Höhlen des Körpers. *Basil*.
- . 1874. Unsere Körperform und das physiologische Problem ihrer Entstehung. *Leipzig*.
- HJORT, J. 1893. Ueber den Entwicklungscyclus der zusammengesetzten Ascidien. *Mitt. zool. Stat. Neapel*, Bd. 10, S. 584-618.
- . 1895. Beitrag zur Keimblätterlehre und Entwicklungsmechanik der Ascidienknospung. *Anat. Anz.*, Bd. 10, S. 215-219.
- HÖRTADYUS, S. 1928. Ueber die Determination des Keimes bei Echinodermen. *Acta Zool.*, vol. 9, pp. 1-191.
- . 1935. Ueber die Determination im Verlaufe der Eiachse bei Seeegeln. *Publ. Stat. Zool. Nap.*, vol. 14, pp. 253-429.
- . 1936. Ueber die zeitliche Determination im Keim von *Paracentrotus lividus* Lk. *Arch. f. Entw.-mech.*, Bd. 135, S. 1-39.
- HOLTERSTEDT, J. 1929. Ueber die Aufzucht isolierter Teile des Amphibienkeimes. I. Methode eine Gewebebeziehung in vivo. *Arch. f. Entw.-mech.*, Bd. 117, S. 422-510.
- . 1933. Die totale Exogastrulation, eine Selbstablösung des Ektoderms vom Entomesoderm. Entwicklung und funktionelles Verhalten nervenloser Organe. *Arch. f. Entw.-mech.*, Bd. 129, S. 670-793.
- . 1938a. Differenzierungspotenzen isolierter Teile der Urodelengastrula. *Arch. f. Entw.-mech.*, Bd. 138, S. 522-656.
- . 1938b. Differenzierungspotenzen isolierter Teile der Anurengastrula. *Arch. f. Entw.-mech.*, Bd. 138, S. 657-738.
- HUNT, T. E. 1937a. The development of gut and its derivatives from the mesectoderm and mesentoderm of early chick blastoderms. *Anat. Rec.*, vol. 68, pp. 349-369.
- . 1937b. The origin of entodermal cells from the primitive streak of the chick embryo. *Anat. Rec.*, vol. 68, pp. 449-459.
- HUXLEY, T. H. 1868-96. "The physical basis of life." In *Method and Results*, New York, 1896. (Lecture delivered in 1868.)
- . 1849. On the anatomy and affinities of the family of the Medusae. *Phil. Trans. Roy. Soc. London*, vol. 139, pp. 413-434.
- . 1869. An Introduction to the Classification of Animals. *London*.
- . 1871-72. A Manual of the Anatomy of Vertebrated Animals. *New York*, 1872 (*London*, 1871).
- KLEINENBERG, N. 1872. Hydra. Eine Monographie. *Leipzig*.
- . 1886. Die Entstehung des Annelids aus der Larve von *Lopadorhynchus*. Nebst Bemerkungen über die Entwicklung anderer Polychaeten. *Leipzig*.

- VON KÖLLIKER, A. 1879. *Entwicklungsgeschichte des Menschen und der höheren Thiere*. Zweite ganz umgearbeitete Auflage. *Leipzig*.
- . 1884. Die embryonalen Keimblätter und die Gewebe. *Zeit. wiss. Zool.*, Bd. 40, S. 179-213.
- . 1889. *Handbuch der Gewebelehre des Menschen*. 6. umgearbeitete Auflage. Erster Band: Die allgemeine Gewebelehre und die Systeme der Haut, Knochen und Muskeln. *Leipzig*.
- KOWALEWSKI, A. 1867a. *Entwicklungsgeschichte des Amphioxus lanceolatus*. *Mém. de l'acad. de St. Pétersbourg*, VIIe Série, T. 11, No. 4.
- . 1867b. Beiträge zur Entwicklungsgeschichte der Holothuriern. *Mém. de l'acad. de St. Pétersbourg*, VIIe Série, T. 11, No. 6.
- . 1869-71. Embryologische Studien an Würmern und Arthropoden. *Mém. de l'acad. de St. Pétersbourg*, VIIe Série, T. 16, No. 12.
- KUCHE, W. 1929. Interplantation umschriebener Zellbezirke aus der Blastula und Gastrula von Amphibien. *Arch. f. Entw.-mch.*, Bd. 120, S. 192-271.
- LANKESTER, E. R. 1873. On the primitive cell-layers of the embryo as the basis of genealogical classification of animals, and on the origin of vascular and lymph systems. *Ann. and Mag. Nat. Hist.*, Series 4, vol. 11, pp. 321-338.
- . 1877. Notes on the embryology and classification of the animal kingdom: comprising a revision of speculations relative to the origin and significance of the germ-layers. *Quart. J. Micr. Sci.*, vol. 17, pp. 399-454.
- LEHMANN, F. E. 1937. Mesodermisierung der präsumptiven Chordamaterials durch Einwirkung von Lithiumchlorid auf die Gastrula von *Triton alpestris*. *Arch. f. Entw.-mch.*, Bd. 136, S. 112-146.
- LINDAHL, P. 1936. Zur Kenntnis der physiologischen Grundlagen der Determination im Seeigelkeim. *Acta Zool.*, vol. 17.
- , AND L. O. ÖHMANN. 1938. Weitere Studien über Stoffwechsel und Determination im Seeigelkeim. *Biol. Zentralbl.*, Bd. 58, S. 179-228.
- , AND ÅKE STORDAL. 1937. Zur Kenntnis des vegetativen Stoffwechsels im Seeiglei. *Arch. f. Entw.-mch.*, Bd. 136, S. 44-63.
- LOPARCHOV, G. 1935. Die Entwicklungseleistungen des Gastrulamesoderms in Abhängigkeit von Veränderungen seiner Masse. *Biol. Zentralbl.*, Bd. 55, S. 606-615.
- *MANGOLD, O. 1923. Transplantationsversuche zur Frage der Spezifität und der Bildung der Keimblätter in der Entwicklung. *Arch. f. mikr. Anat. und Ent.-gesch.*, Bd. 100, S. 198-301.
- MARCHAND, F. 1899. Ueber die Beziehungen der pathologischen Anatomie zur Entwicklungsgeschichte, besonders der Keimblattlehre. *Verh. d. deutsch. patholog. Gesellsch. München*, Jahrg. 2, S. 38-107.
- MARX, A. 1925. Experimentelle Untersuchungen zur Frage der Determination der Medullarplatte. *Arch. f. Entw.-mch.*, Bd. 105, S. 20-44.
- MINOT, C. S. 1901. The embryological basis of pathology. *Sci.*, N. S., vol. 13, pp. 481-498.
- OFFENHEIMER, J. M. 1938. Potencies for differentiation in the teleostean germ-ring. *J. Exp. Zool.*, vol. 79, pp. 185-212.
- PANDER, C. 1817a. Beiträge zur Entwicklungsgeschichte des Hühnchens im Eye. *Würzburg*.
- . 1817b. *Dissertatio inauguralis, sistens historiam metamorphoseos, quam ovum incubatum prioribus quinque diebus subit*. *Würzburg*.
- PENNER, A. 1924. Experimentelle Untersuchungen zum Determinationsproblem am Keim von *Tubifex rivulorum* Lam. I. Die duplicitas cruciata und organbildenden Substanzen. *Arch. f. mikr. Anat. u. Entw.-gesch.*, Bd. 102, S. 51-100.
- . 1926. Experimentelle Untersuchungen zum Determinationsproblem am Keim von *Tubifex rivulorum* Lam. II. Die Entwicklung teilweise abgetöteter Keime. *Zeit. wiss. Zool.*, Bd. 127, S. 1-140.
- . 1937a. Regulation am Keim von *Tubifex rivulorum* Lam. nach Ausschaltung des ektodermalen Keimstreifs. *Zeit. wiss. Zool.*, Bd. 149, S. 86-130.
- . 1937b. Abhängigkeit der Formbildung vom Mesoderm in *Tubifex*-Embryo. *Zeit. wiss. Zool.*, Bd. 150, S. 305-357.
- RATKE, M. H. 1825. Flusskrebs. *Isis von Oken*, Jahrg. 1825, Theil 2, S. 1093-1100.
- . 1829. Untersuchungen über die Bildung und Entwicklung des Flusskrebses. *Leipzig*.
- REMAK, R. 1850-55. Untersuchungen über die Entwicklung der Wirbelthiere. *Berlin*.
- RUNNSTRÖM, J., AND S. 1918-19. Ueber die Entwicklung von *Cucumaria frondosa* Gunnerus und *Psolus phantapus* Strussenfelt. *Bergens Mus. Aarbok. Naturv. Raekke*, 5; 9.
- RUSSELL, E. S. 1916. Form and Function. A Contribution to the History of Animal Morphology. *London*.
- SEDGWICK, A. 1910. "Embryology." In *Encyclopedia Britannica*, 11th edition, vol. 9, pp. 314-329. *Cambridge*.
- SPEMANN, H. 1912. Ueber die Entwicklung umgedrehter Hirnteile bei Amphibienembryonen. *Zool. Jahrb.*, Suppl. 15, pp. 1-48.

- SPERMANN, H. 1918. Ueber die Determination der ersten Organanlagen des Amphibienembryo I-VI. *Arch. f. Entw.-mech.*, Bd. 43, S. 448-555.
- , AND H. MANGOLD. 1924. Ueber Induktion von Embryonalanlagen durch Implantation artfremder Organisatoren. *Arch. f. mikr. Anat. und Entw.-gesch.*, Bd. 100, S. 599-638.
- VON UBISCH, L. 1929. Ueber die Determination der larvalen Organe und der Imaginalanlage bei dem Seeigelkeim. *Arch. f. Entw.-mech.*, Bd. 117, S. 80-122.
- . 1933. Formbildungsanalyse an Seeigellarven. *Naturwiss.*, Jahrg. 21, S. 183-186.
- VOGT, W. 1925. Gestaltungsanalyse am Amphibienkeim mit örtlicher Vitalfärbung. Vorwort über Wege und Ziele. I. Methode und Wirkungsweise der örtlichen Vitalfärbung mit Agar als Farbträger. *Arch. f. Entw.-mech.*, Bd. 106, S. 542-610.
- WOLFF, C. F. 1759. *Theoria generationis*. Halle.
- . 1812. Ueber die Bildung des Darmkanals im bebrüteten Hühnchen. Uebersetzt und mit einer einleitenden Abhandlung und Anmerkungen von Johann Friedrich Meckel. Halle. Originally published by Wolff as follows: *De formatione intestinorum praecipue, tum et de amnio spurio, aliisque partibus embryonis Gallinacei nondum visis*. *Novi Comment. Acad. Sci. Impt. Petropol.* vols. 12 and 13, 1768-69.
- WILSON, E. B. 1894-96. The Embryological Criterion of Homology. Biological Lectures delivered at the Marine Biological Laboratory in the summer session of 1894. Boston.





THE FAUNA OF THE SOIL

By ARTHUR PAUL JACOT

Northeastern Forest Experiment Station, New Haven, Connecticut

INVESTIGATIONS during the last twenty years have revealed a microcosm within the soil and its litter, which is as complex as that of fresh water. In contrast to the plancton, the geenton is specialized for slow movement through a dense granular medium.

Soil was originally conceived as composed of minute, irregular grains separated by interstices between the grains known as the pore-space. We now know this to be the least significant factor in soil structure. Of far greater importance is the maze of innumerable intertwining channels permeating every cubic inch of unplowed vegetated soil, channels formed and maintained by a host of animals common to that medium (67).

This fauna may be considered from two view-points: (1) the effect of its various members on the soil (a) in increasing channeling and therefore rain receptivity, i.e. in decreasing run-off and floods, (b) in increasing fertility and consequent more rapid growth of wood, (2) the interrelations of these animals through their feeding and breeding habits. The first is of economic value, the second is of sociologic interest.

EFFECT OF THE FAUNA ON THE SOIL

The simplest introduction to the animals is through a study of their effect on the substratum, which is also the source of food of all the life of field and woodland. The skein of interrelations will thereby become more apparent.

Included in the soil and an integral part of it, is the litter of plant parts and animal

remains which form a covering over the surface of the mineral soil. This organic covering is most conspicuous as a carpet of dead and mouldering leaves which is gradually reduced by the action of bacteria, fungi, and a part of the fauna, to a litter of minute faeces which lies immediately over the mineral soil or is mixed into the mineral soil by various animals which may be conveniently referred to as *mixers*.

As affecting the mineral soil then, animals may be grouped under three heads: reducers (of litter), mixers (of organic residues and mineral soil), channelers (of the soil). To be of greatest value, soils must incorporate an adequate supply of all three groups.

Although forest soils are the most complex and bear the largest population, all other subaerial soils are similar, differing in being simpler and in having a more meager and a more specialized fauna. The richness of the fauna varies with the amount of available organic (chiefly plant) material. Where plants can grow, animals will thrive. By using as an example the soil fauna of the woodlands of the northeastern United States, the reader will envisage the framework of the populations of soils throughout the world. The number of species and the kinds of species change from one region to another, but their functions and interrelations remain the same. However, the influence of any one type of animal or of any one species varies greatly in its *intensity* locally. The present review will confine itself to the fauna of the mineral soil.

The deeper the organic covering, the fewer animals can reach the mineral soil. Thus, a layer of raw humus fifteen inches deep exercises a marked effect on the population in the mineral soil beneath it.

THE VERTEBRATES

The rôle of mammals

Mammals influence the soil in four ways: by manuring, trampling, mixing, and channeling.

All mammals manure the soil, though to varying extents, depending upon the size of the animal, its local abundance, and its food habits. Herbivorous animals defecate more than do carnivorous animals. The greatest dungers are the large herbivores, but the value of their contributions is lessened by the effect of their trampling.

Trampling and compacting of the soil is effected chiefly by the gregarious herbivores. This may be seen by anyone living in dairy country. Cows as well as many species of hoofed animals follow each other from place to place in single file. In this way paths are established. In fly time the paths lead through brush or clumps of bushes. When these bushes become frayed, trampled or otherwise inefficient in brushing off the flies, the cows start a new trail through other bush clumps. In this way their paths shift laterally. The daily passage of a herd of cows over a woodland trail compacts the soft, woodland soil so much that the level of the trail soon lies three to eight inches lower than the level of the forest floor. In open pastures, trails are shifted on the slopes so that an overgrazed pasture slope bears a net-like pattern of trails. This is as true of sheep as of cows.

In order to limit or reduce this trampling, it is necessary to limit the numbers of the larger hoofed animals per acre.

Many of the smaller mammals shelter and nest in the soil. For this purpose dens are excavated, the depth or extent of which varies with the species. In the east, woodchucks and chipmunks (22, pp. 238-245) are the best known and most typical soil diggers, though the habit is also shared by bears, otters, foxes, wolves, jumping mice (*Zapus* in meadows and *Napeozapus* in woodlands), and short-tailed shrews (*Blarina*). The effect of this digging is to throw mineral soil out over the organic layers. Most of these animals carpet their subterranean nests with dead leaves.

The burrows of woodchucks may be as much as twenty-five feet long with various galleries and nest chambers in the sides (90, p. 275). The nests are stored with dead leaves even though they have to be carried for many feet. It is problematical whether the woodchuck or the earthworm buries most leaves per annum per county.

Rabbit nests are about as big as a coconut, the bottom lying at least six inches below the level of the soil (17, p. 161).

However, the work of the larger diggers is so local, that its effect on the soil is of minor importance, except over a period of decades.

Blarina extensively tunnels the humus layers and builds a nest approached by many burrows usually occupying two levels, the nest being in the lower level and on the mineral soil. This complicated structure is usually built in a mound or hummock of organic material (decayed stump, log, or humus). The nest is furnished with a double handful or so of dry leaves. There may be ten to fifteen such nests per acre.

In addition to digging to make shelters and nests, some mammals dig to obtain food. The skunk makes deep narrow

holes in the earth by which it probes for insects (90, p. 105).

"During the succeeding half hour, it [a skunk] did not cover a space greater than three or four rods square, but literally every foot of this area was carefully inspected. Not content with rooting into every bunch of dead leaves, it dug dozens of holes, first plunging its sharp nose into the ground and then using its fore-feet, making the dirt fly. Its hole was only a few yards distant" (17, p. 124).

Large numbers of insect larvae, as white grubs (*Lachnosterne*), wire worms, alfalfa weevils, are eaten, for which they dig into the soil to a depth of two to four inches. During the early spring (April-May) field mice form a major share of the food although they have to dig to a depth of a foot to capture the mice (56).

Some animals dig for storage of food. The grey and fox squirrels dig small holes in the ground and deposit a nut or acorn in each cavity, carefully replace the soil, press it down, and cover the spot over with leaves. They may thus pepper the ground of their territory with such "plantings."

Soil tunneling is much more general and extensive than nest excavations, though possibly not as beneficial to the soil. Moles and voles are the most highly developed tunnelers among the mammals. In the east, the common mole (*Scalopus aquaticus*) pushes its tunnels through all fairly dry, sandy, or loose loam. It does not channel dry, compacted soil. At best its effect is to render good soil more loose and more open. It is a decided aid to percolation of rain water by breaking up the soil surface. Although any one tunnel or mole ridge may be very narrow (three to four inches) the mole is a very active animal and may throw up two hundred to three hundred feet of ridges every twenty-four hours during the growing season. They are also active during the winter. Further-

more, they are very useful in destroying June beetle larvae and other such noxious insects, especially when they become numerous. They do not eat bulbs and corms. Their diet of worms, however, is not to their credit. They should not be exterminated in woodlands unless their enemies are also exterminated. In wet soils, swamps and bogs the common mole is replaced by the star-nosed mole (*Condylura cristata*). Its burrows (1.3-3 inches wide and 1.5-2 inches high) extend along streams, ponds and lake shores, opening under water. There may be five per acre in swampy terrane. They feed from muck beds and stream bottoms on aquatic insects and worms.

The pine mouse (*Pitymys*) forms intricate and extensive burrows like those of the mole, in open wooded areas as well as in open land. Their caches extend to eighteen inches below ground. They do not range into the transitional zone. I have seen a forty-year-old white pine plantation with the upper two inches of the mineral soil completely honeycombed by this species.

The red-backed mouse (*Clethrionomys*) lives in similar burrows near the surface, especially in evergreen woodlands.

The meadow mouse (*Microtus*) makes very extensive burrows chiefly in meadows but also in marshes and even in swamps, storing them with vegetation.

Lemmings (*Synaptomys*) construct burrows about the edges of bogs, swamps, or even in drier areas of low cover.

The short-tailed shrews (*Blarina*) also tunnel in the surface soil, especially the humus, but only in soft earth and near water. As they tunnel chiefly in loose soil and humus, they are of doubtful value as soil channelers. The other shrews utilize the runways of other animals.

The influence of birds, reptiles and batrachians

Birds affect chiefly the litter by manuring and by scratching. Song sparrows, Juncos (17, pp. 71, 120), Lincoln sparrows (p. 140), red-polls (p. 225), fox sparrows and towhees are among the smaller scratchers. They certainly can make the leaves fly, but they do not materially affect the mineral soil. Pheasants and grouse, meadowlarks and others dig into the mineral soil with their bills to extract white grubs or tubers and the like, to a depth of an inch and a half or even two inches (teste A. A. Allen). Woodcock and snipe probe in soft soil to a depth of three inches.

Bank swallows excavate burrows (2.5 inches x 1.5 inches) to a depth of 36 inches below the overlying turf. Although a bank may contain thousands of such burrows, a few inches apart, most colonies comprise only one or two dozen pairs of birds. As they make new nests each season (88) their local effect in dislocating mineral soil is considerable. Since the nests (an enlargement of the burrow) are lined with straws, grasses and feathers the birds locally enrich the mineral soil for the vegetation above the bank. On the well-drained uplands where the soil is mostly hard-pan, shale, or rock this species is not found (36, p. 351).

Kingfishers are not so exacting in soil type and are therefore more generally distributed. Moreover, their burrows are $3\frac{1}{2}$ inches in diameter, 4-8 feet deep, and terminated by a nest 8-10 inches in diameter and situated fairly close to the turf. Their organic contribution is phosphate-rich fish parts. Even if they are of more value in soil improvement than bank swallows, their effect is almost as local, and cumulative only over a long period of years (36, p. 138).

Although some birds on some oceanic islands honey-comb the mineral soil with their nest burrows, and on certain restricted tracts, birds overload the soil with their droppings, the effect of birds on soils generally is of a minor nature or extremely local. In our region their effect on soils is greatest on sand and gravel banks and terraces.

Of the three groups of reptiles, lizards, snakes and turtles, the latter are much the most important diggers. The box turtle and the wood tortoise are typical woodland species. They dig not only to lay their eggs but also to hole-up for the winter. Other turtles do likewise but their digging is confined to the borders of streams, ponds, marshes and swamps, or to sandy areas and sand and gravel banks. Such holes may be as broad as the turtle and nearly a foot deep (17, pp. 75, 129; 90, pp. 54, 65, 91, 105, 178, 179). All things considered the effect of turtles on the soil is noteworthy over a period of years in sandy places near water and in swamps.

Regarding batrachians: there is very little information on the digging and burrowing capacity of salamanders, though they are common in moist woodlands, especially where littered with stones. Toads dig out shelters in the soil, large enough to completely cover themselves. In suburban areas there may be a toad to each garden. In the White Mountains along the slopes above the Greeley Ponds a toad was disturbed nearly every linear rod. The unusual abundance here may be due to the deep humus which they can easily excavate. Their commonness about dwellings is due to absence of natural woodland predators. In woodlands with little humus and numerous predators toads are uncommon. Thus batrachians are of only minor importance in their effect on soils, especially on the

mineral soil—local concentrations excepted.

All the above-mentioned soil influents are to be encouraged as contributors in their own small way to soil improvement. It should be remembered that the effect of all these animals together (collective effect) over a period of time (cumulative effect) is a concrete contribution.

THE INVERTEBRATES

Our knowledge of the invertebrate animals of woodland soils is very meagre. Most of the investigations on soil invertebrates are restricted to crop soils and grasslands (meadows). Similarly we are much better acquainted with the fauna of the litter of woodlands than of the underlying mineral soil. Bornebusch's report (7) still remains the outstanding contribution on the fauna of forest soils.

The effect of higher insects

Of the various groups of invertebrates the higher insects form a natural, homogenous group. These animals spend a part of their lives above the soil and litter, using the latter for hibernation, aestivation, oviposition, and as a medium or shelter for the immature stages. The latter are frequently so different from the adult form as to constitute a special field of study. Since the higher insects are able to fly they are highly motile and therefore usually thinly sprinkled—especially the larger species.

Psocids

"Book-lice," especially of the subfamily Caccilinae, are fairly common in litter (usually only the wingless forms are obtained from drying funnels) but do not materially affect the soil (23, 4).

Hemiptera

Weese (98) and Blake (6) found that during the later autumn certain leaf-

hoppers (Cicadellidae) and lace-wings (Tingidae) migrated from the forest border into the forest to hibernate in the soil. They give no indication of the numbers of the various species per unit area! Mealy bugs are common soil insects in some localities (67).

Cicadas are woodland insects which spend most of their immature life in the soil. Their migration down into the soil and search for a rootlet to suck on is affected when still very small (a few days after hatching). The immature stages, whether extending over a few months or seventeen years, are spent in an earthen cell six to twelve inches below the surface. In late autumn they migrate downward to a depth of two feet (latitude of Washington, D. C.) to hibernate, returning to the six- to twelve-inch stratum in the spring. They may be so abundant that the individuals are two to four or five inches apart—all within the same general soil layer. Marlatt (71) records nine per square foot in a dense oak forest of Washington, D. C. When ready to emerge, the exit holes (averaging $\frac{5}{16}$ of an inch in diameter) are formed some time before emergence actually takes place. Thus the annual or biennial species are more important as soil channelers than the thirteen- and seventeen-year species.

At least nineteen genera of aphids are subterranean, feeding on plant roots. Although some species pass part of their life cycle on other hosts above ground, some of them pass their entire life cycle in the soil. Some species are restricted to certain host plants while others enjoy a varied diet. The food is sought by wandering about through the soil (30). Many species, however, depend upon ants to carry them to their food while in the egg stage. In the case of the corn-root aphid (*Aphis maidiradicis*) the eggs are stored below frost line by the ants and

placed on the roots of the host plant in the spring (33). Soil aphids are to be found on roots of forest trees as well as on roots of grasses and cultivated plants. Roots of the following plants are recorded as hosts: grasses, Polygonaceae, legumes, Rosaceae, various herbs, *Barbarea*, *Alnus*, *Abies* (58, pp. 448), Composites (33). They occur to a depth of at least two feet. Since they are of general occurrence, and stimulate ants to do a good deal of soil channeling in order to insure an adequate supply of food on which to maintain their honey-dew cows, their effect in soil channeling is noteworthy. (Their effect on forest regeneration, through seedling mortality is also noteworthy.)

Thysanoptera

Although *thrips* are to be found in litter which is not wet, even to the extent of 200 per bushel, or a dozen per square foot of surface, they are not known to affect soil structure (95a, p. 44).

Orthoptera

Of the various families of Orthoptera, the Acridids (grasshoppers), Locustids (katydids), and Gryllids (crickets) affect the soil to the extent of drilling the surface to lay their eggs. This drilling varies in depth with the size of the insect, length of ovipositor, and extent to which the abdomen is worked into the soil. It varies in intensity with population density. Population density varies with soil type. Sandy soils, dry soils, exposed (thinly vegetated) soils support dense populations of Acridids; moist soils with dense herbaceous covering (meadows) support a fairly dense orthopteran population. Woodlands especially dense, moist woodlands, harbor but few grasshoppers though they are common along dry woodland edges and openings.

Typical woodland species of southern

New England are: *Chlorelis conspersa*, which lays its eggs in dry sticks and logs; *Spharagemon saxatile*, on high wooded ledges; *S. bolli*, in open woods; *Melanopus punctulatus*, among pines (oviposits in the thick bark or crevices of the trees); katydids and camel-cricket, about logs and stone piles; ground crickets (*Nemobius carolinus*), in open woods; *N. maculatus*, in low open woods about logs (95). (Tree-crickets do not oviposit in the soil.) Thus woodland grasshoppers occupy special niches in the forest and have various habits of oviposition. Mole crickets burrow about in the soil much like moles, but in New England are confined to such sites as stream and pond margins. Some mole crickets in other regions burrow about in dry soil.

In favorable situations and conditions, one of the commonest medium-sized species of grasshoppers will inter 125,000 egg masses per acre. These require a hole one inch deep by three-sixteenths in diameter (62). Oviposition occurs once or twice annually, preferably in undisturbed fairly compact soil. Different species oviposit at different times through the spring and summer. Dry fields and meadows may harbor as many as six to ten species of grasshoppers; heavy moist woodlands, none.

Thus the effect of the Orthoptera in drilling the soil surface may be locally intense to negligible. The effect of katydids and camel or other crickets in woodland soils is usually not notable though it might become locally intense, especially in areas and countries where woodland species occur to any extent.

Lepidoptera

Many caterpillars pupate in the soil, different species to different depths, even to ten inches. Conversely certain Sesiidae tunnel four to seven inches up through the

soil from the tree roots, in which they have been burrowing, to the soil surface to pupate (54). Although the hawk-moths make the largest burrows (three-eighths inches or more in diameter) they do not usually occur in great numbers. The canker worms (*Paleacrita*) burrow into the soil to a depth of from two to five inches to pupate. The Citheroniidae (Ceratocampidae) pupate in the soil to hibernate. Some species are single brooded (*Anisota virginiensis*), others have two broods per year (*A. rubicunda* and *A. stigma*). Most of them feed on forest trees including persimmon, gum, cedar, cherry, and sassafras. *Anisota senatoria* pupates three to four inches below the surface of the ground to overwinter. It occurs in abundance only over small areas at any one time. The green maple worm (*Xylina antennata*) has similar habits (61, 47). When at times any of these species cause serious defoliation of trees, the numbers entering the soil would considerably affect soil structure.

Since many of the lepidopterous larvae are over an eighth inch in diameter, their effect in soil channeling is of note where they occur to any extent. I fail to find data on their relative numbers in forest soils. Such figures would vary from month to month since different species pupate during different months. In Danish forest soils (7) larvae were only occasionally found (they very quickly pupate) while pupae would tend to remain undiscovered on the drying funnels. To obtain such numerical data, square meter soil samples would have to be taken through the year and to a depth of three feet, and the soil sieved.

Since several hundred species pupate in woodland soils in the northeastern states (teste Forbes) the effect of Lepidoptera on soil structure is noteworthy. Very locally, sporadically, and occasionally, it

becomes intense. Their collective and cumulative effect is considerable and may be controlled in part by encouraging the growth of the food plant of each digging species.

Hymenoptera

Certain sawflies burrow into the ground to pupate. The ash sawfly (*Tomostethus multicinctus*) pupates in an earthen cell about half an inch in the soil. The elm leaf-miner (*Kaliopfenusa ulmi*) enters the soil to a depth of about an inch to pupate (61). The larvae of the blackberry leaf-miner (*Scolioneura*) burrow six to eight inches into the soil to overwinter and pupate (31).

Some Calcids and Cynipids enter the earth to pupate. Some Cynipids (*Belonoctema*) form root galls in sandy places (Florida and Texas) (99). They are, however, extremely local.

Most of the digger wasps of the families Pompilidae, Sphecidae, Larridae, Bembecidae, Philanthidae, Crabronidae and some of the solitary wasps (Eumenidae) dig burrows (either simple or variously branching) in the earth to lay their eggs—usually in sandy or sunny (dry) places (27). *Sphecius speciosus* (an inch and a quarter in length) digs burrows two feet or more in depth (27). The digger wasp *Ammobia ichneumonaea* (L) digs a nest tunnel 5–7 inches long, to a circular chamber 1 inch in diameter, from which radiate 2–6 tunnels 1–2 inches long, ending in oval cells 1½–2 inches long and ¾ inch wide. These are stored with 2–6 grasshoppers (50).

The Scoliids (*Tiphia* and *Elis*) burrow about through the soil in search of their host the June beetle larvae and related genera (34).

Some of the social wasps (Vespidae) build their nests in hollows which they excavate in the soil. As the colonies

exist for only one season—each overwintering female starting a new colony in the spring—they are one of the most active soil movers among the insects. I well remember how frequently my ankles burned while tramping about through an old growth stand of long leaf pines in the Piedmont of South Carolina, and how frequently I was prevented from taking a litter sample at chosen points by these soil inhabiting yellow-jackets. *Vespula* may build their large (10 inches x 6½ inches) nests in hollows in clay banks or in the forest floor nine inches below the surface. These nests have a burrow running back from the nest for as much as one hundred and fifty-nine inches and to one inch in diameter (69). Some of the species of the solitary wasp *Cerceris*, which is colonial, dig a tortuous burrow to twenty-four inches long and to seventeen inches deep, with galleries one and a quarter inches long for the larvae. The burrows are from half to three-quarters of an inch in diameter. Thus an area inhabited by such a colony would be pretty well riddled with fairly large burrows. Fortunately, the colonies are limited in number (81).

Many of the solitary bees (Apoids) make their nests in mineral soil. They are difficult to find because the entrance is hidden—as by the leaf of a rosette plant. Some Andrenids excavate more or less branched tunnels, each branch stocked with a single egg (and food). The main shaft of the one nest of the larger Andrenas (the size of a honey-bee) exceed a foot in depth. As some of these bees are colonial, a square rod of ground may include several thousand such nests (27).

Species of *Halictus* burrow in sides of clay cliffs and sand banks. Several females cooperate in sinking the main shaft, from which they individually dig out their several galleries, thus forming

"cities composed of apartment houses" (27). Some *Megachiles* dig simple burrows in the soil in which they build egg or brood cells end to end.

In general, wasps and bees are not common in moist woodlands, preferring dry, sunny woodlands and open places. Colonies are commonly found in bare places with good drainage. Thus their annual contribution to soil structure in mesophytic woodlands is rather meager.

Of all the Hymenoptera, perhaps of all the insects, the ants are by far the most important soil movers. Even if, like all Hymenoptera, they are not abundant in moist woodlands, they are as important in dry woodlands and in grasslands as are earthworms in moist woodlands. In a weedy abandoned field in northern New York, I have seen a colony on nearly every square yard, spreading the yellowish soil in discs as large as a stove lid over the black surface soil. Although they spread a great deal of mineral soil over the organic litter, they do not draw an appreciable amount of organic litter into their galleries. Even those species which store their nests with plant seeds, clean off the pappus, and abandon the thin unfertilized seeds brought in by some workers, where they accumulate outside the nest as a midden heap at the entrance. The commonest woodland ants in the mesophytic woodlands of the east are *Ponera coarctata pennsylvanica* and *Myrmecina graminicola brevispinosa*. These primitive species form small colonies but occur in every square yard of the woodlands. There are several other ants nesting in our mesophytic woodlands but all of them nest under stones and in humus (101), so that the amount of soil they move is negligible. Although the large carpenter ant (*Camponotus pennsylvanicus*) is common in woodlands it does not enter the mineral soil. Although the mound-building ant (*For-*

mica exsectoides) forms conspicuous mounds two to five feet across, thereby moving a large amount of soil, it is found only in glades and open places; its effect is therefore very local.

The only study on quantitative distribution of ants was carried out on the steppe formation (75). In the tchernozem soils, one square kilometer contained an average of 415,000 nests; alkali soil, 340,000 nests; saline soil, 257,000 nests. Factors influencing the distribution of the ants were composition and density of the vegetation, soil moisture, exposure, presence of other animals. The lowest and most wet areas were entirely devoid of ant nests!

Thus ants are as unimportant a factor in soil structure in mesophytic woodlands as they are an important factor outside of such moist shelter.

Diptera

Flies affect the soil in oviposition, as a retreat for pupation, and as the medium of the immature stages of certain families. Their effect varies with the size, extent of burrow, and local abundance of the species (29).

Some Tipulid larvae live in decaying wood, in soil of all types, eating roots, earthworms and other soft-bodied animals (3). Although they occur in nearly every square foot of litter, their presence in the soil is conditioned by the depth of the humus layer. In Denmark Tipulid larvae were found in the soil only occasionally (that is, one in every seven square-foot samples: maximum number in one sample, nine) (7).

Some Cecidomyid larvae live in decaying organic matter, many pupate in the soil, others live in roots forming galls, still others are predators on mites and insects. In Denmark they were found only in soils of resinous woodlands and to

a maximum of twenty-one in one square foot (7).

Many Chironomid and Sciarid larvae live in moist organic soils and decaying organic matter. They are scavengers. Sciarid larvae are common in spruce litter.

Some Mycetophylid larvae live in rich soil, in decaying wood, in decaying vegetation and such plant parts as rotting grains, green bulbs, potatoes, and roots. In Denmark (7) they were obtained in large numbers in July and November (maximum in a square-foot sample, 125). *Phaenocladus* is one of the common soil genera, especially under pine, for the larvae eat out decaying pine twigs.

Psychodid larvae live in decaying organic matter and dung. Bornebusch (7) recovered them only in the soil of a beech duff during March and November (maximum in a square-foot sample, 17).

Leptid larvae are common in most forest soils. In Denmark (7) they were found on an average of four or five per square foot, not infrequently thirteen or fourteen.

Anthomyid larvae are common in soils of deciduous forest although very irregularly distributed. In Denmark their numbers ranged from none to one hundred and sixty-six per square foot.

Therevid larvae live in earth, certain species forming side channels to earthworm burrows. Some are saprophagous, others are predaceous on insect larvae.

Some Bibionid, Mydoid, Coenomyid, Asilid, Tabanid, Dolichopodid, and Bombyliid larvae are predaceous in rich soils (29). Certain Bibionid larvae live in decaying vegetation and grass roots, others hibernate in the soil (7). Asilid larvae burrow about in upland soils, Tabanids in low and marshy ground where they seek their prey, June beetle larvae and related genera. Some Dexid, Tachinid, and Bombyliid larvae search through sandy and porous soils after other species

of June beetle and related larvae. In Denmark Dolichopodids were found in soils under beech and pine to a maximum of twelve to a square foot.

Trypetids, such as the walnut husk-maggot (*Rhagoletis suavis*), pupate from half an inch to several inches in the soil (19). Certain Tachinids pupate in the soil to a depth of one inch, especially about the base of trees (28). Some Agromyzids pupate two to three inches in the soil (64). Such Sarcophagids as *Chrysomya macellaria* pupate from one to four inches in the ground (5).

The genera *Forcipomya* (Ceratopogonid), *Fannia* (Muscid), and *Lonchoptera* (Lonchopterid), were recovered by Bornebusch in one or two stands only, and in very small numbers.

No square foot of forest litter or soil is without fly larvae, so that their influence on soil structure is noteworthy. Although their cumulative and collective effect is important, their control is problematical.

Coleoptera

Beetles affect soil by burrowing into it to lay eggs, to pupate, to form retreats (for hibernation), and to feed on plant roots.

Tiger-beetle larvae form definite burrows in the soil, some species using a definite and characteristic soil type. The burrows may be perpendicular to the surface, spiral, slanting or otherwise, and as much as thirty-nine inches and even seventy-two inches deep, depending on the species and the latitude. The burrows of many species are over a foot in depth. The larva occupies its burrow for ten months to twenty-one months, unless found unsuited when it seeks better soil conditions to make a new burrow. Some species are colonial, others solitary. Mesophytic woodlands are avoided, most

species preferring sunny, bare areas, often openings between plants. *Cicindela sexguttata* will burrow under fallen trees and in partly cleared places and glades. *C. scutellaris lecontei* was found in greatest abundance where oaks begin to displace the pines—near Chicago (55).

The large Carabids of the genus *Calosoma* lay their eggs singly or in groups of two or three, at least four to six inches in the soil. The larvae pupate eight to ten inches deep in soft soil, or less in compacted soil. Their numbers may reach twelve per square yard when caterpillars are abundant (21). Carabids of the genus *Clivina* migrate through the soil from near the surface to as much as two feet, as the surface soil becomes too dry (80). Bornebusch records an average of less than one adult or larva per square foot in mull soils, with a maximum of three or four (7).

Elaterid larvae burrow about in the soil. Some live in the soil for as much as three years before pupating (65). During the winter the larvae descend to from four to six feet for hibernation (53). Although nearly every square foot of forest litter harbors Elaterid larvae, their abundance in the mineral soil varies locally. Different species are partial to different soil types (degree of compactness and moisture) (52). Bornebusch records an average of about eighteen *Althous* larvae per square foot in raw humus, with a maximum of fifty-one, but only an average of two per square foot in mull soil (7). They eat plant seeds, roots, and decaying wood.

The Heteroceridae live in burrows which they excavate in sand or mud at the margins of bodies of water (27).

Certain Staphylinid larvae live in the soil (94). The large golden Staphylinid, *Creophilus villosus*, lays its eggs in the soil where it spends its thirty-seven days of

predaceous larva-hood before pupating in an earthen cell (1). Although nearly every square foot of forest litter contains Staphylinids, their occurrence in the soil varies with the depth of the humus layer. Bornebusch records an average of two larvae and two adults per square foot of mull soil, with as many as twenty-five in raw humus.

Certain Chrysomelids (*Galerucella*, *Lema*) pupate in the soil (43). The linden-leaf beetle (*Calligrapha scalaris*) enters the ground to pupate and later reenters as an adult to hibernate (102). Various flea-beetles pupate in the soil to three inches deep (24, 70, 87). Some flea-beetle larvae are root eaters.

The Scarabaeids include many species, the larvae of which live in the soil. Some feed on roots, some on decaying wood, and others on dung buried by the parents (27). June beetles (*Lachnosterum*, *Phyllophaga*) spend three years burrowing about in the soil (46). Of the many species, some are woodland, feeding on the rootlets of seedling trees. The eggs are deposited from one to eight inches below the surface in balls of earth formed by sticking particles of soil together. In the autumn the young grubs burrow downward to pass the winter. "In the spring they move upward, eat ravenously, do their greatest damage this second summer, and, migrating downward in the autumn, spend a second winter deeper in the soil. In the second spring they return toward the surface, feed for a time, and transform to pupae in earthen cells in June" (61). As there are three broods, the three stages occur in the soil each year. June beetle larvae are characteristic of cultivated sites where they may occur to the extent of ten or eleven per square foot; woodlands, however, harbor related species. *Cyclocephala villosa* larvae

spend about 350 days in the soil; *Anomala binotata*, 85 days (59).

Larvae of Japanese beetles live a few inches below the surface, burrowing about in search of food. The maximum number is 46 per square foot (in grassland). Females burrow into the soil 2-4 inches to deposit their eggs every day or two for a period of 30-45 days (44). Geotrupes excavates a dung pit for each egg. Woodland species have corresponding habits.

Bornebusch records less than one Cantharid larva per square foot of mull soil with a maximum of twelve. They show a preference for mild deciduous woodlands.

Adult Ptiliids (Trichopterygids) occurred in beech mull soil of Denmark (7) on an average of one per square foot (maximum is twelve) but were much more abundant in oak mull soil.

Some of the larvae of the large Prioninae feed upon roots of woodland trees (27).

The hickory nut weevil (*Balaninus caryae*) enters the soil to a depth of six to eight inches to pass the winter. The five species of *Balaninus* attacking the different species of acorns have similar habits. The hickory nut and butternut curculios (*Conotrachelus affinis* and *aratus*) also pupate in the soil from half to three inches in depth (20). Other curculios (*Polydrusus*, *Phyllobius*, *Oriobrychus*) pass the larval stage in the soil feeding on tree and plant roots (78). Bornebusch records curculios chiefly in oak mull, sometimes as many as five per square foot (7).

Weese (98) and Blake (6) found that during later autumn certain beetles of various families migrated from the forest border and from surrounding fields into the forest to hibernate in the soil—some less than 10 cm. (four inches), some more than 10 cm. deep. They give no indication of the numbers of the various species per unit area!

Thus beetles are one of the most important orders of insects in channeling the soil, especially in open places and in relatively dry soils.

Higher Insects—General Summary

The foregoing review though comprised of odds and ends of examples indicates two fundamental phenomena: (1) that the higher insects use woodland soils as places of shelter, hibernating in the soil during the winter, (2) that a large percent of the higher insects prefer dry, sandy, sunny (warm) soils for nesting sites. Unfortunately most of our knowledge of soil insects has been restricted to agricultural land. We do know, however, that certain families and genera of the higher insects are common in moist forest soils. Leptids, Staphylinids, *Altbous* (Elaterid), Anthomyids in nonresinous, Ceccidomyids in resinous woodlands are the outstanding groups in soils of mesophytic woodlands. It should further be recalled that most of these insects spend only a part of their lives in the mineral soil and are, therefore, not geobionts but geophiles (67).

Though some of the higher insects annually enter forest soils for hibernation as adults, we are ignorant of the extent (number of species) or intensity (number of individuals per unit area of surface) of this periodic type of soil channeling. Finally, the literature on the higher insects which inhabit the soils of the woodlands of the northeastern states is not only very scattered but extremely fragmentary.

The primitive insects (Microarthropods)

The species grouped under this head are minute and wingless, and transform from larvae to adult by very gradual stages. Most of them are poorly sclerotized, lack organs of defense and offense, and are not highly colored (with the ex-

ception of some of the springtails). They are the commonest insects of the mineral soil, ceaselessly threading its many channels, thereby helping to keep them open. They are either saprophagous, coprophagous or suckers. These insects freeze up during the cold weather and thaw out when warm, thus being active whenever their medium is above freezing. Since they are apterous they must be close enough to each other to meet and mate within their short adulthood. Thus they are to be counted by the dozens or hundreds per square foot while each species of the higher insects are usually represented by less than half a dozen individuals per square foot or by one or two per square yard. The ratio of immature to adult is very high, signifying a great mortality. They are therefore a very important source of food to the small predators. The largest group is the:

Collembola

Springtails abound in all moist or fairly moist soils to unknown depths. Volz (93) analyzed square decimeter (2 cm. deep) samples from woodland soils near Leipzig, taken at depths of over 10 cm. (15-17 and even 35 cm.). He found *Folsomia quadrioculata* in half the samples, often one specimen but up to seven. It is much more abundant in the upper layers and in the litter, but was absent in some of the spruce woodland samples, though common throughout the year. It is common in most habitats in Greenland (57) and is one of the commonest humus species in the White Mountain region. *Onychiurus armatus* occurred in half the samples, two or three (maximum six) per sample, though more common at less depth. *Onychiurus ambulans* was found in only two out of sixteen samples below fifteen centimeters. *Tullbergia krausbaueri*

occurred in half the samples (especially in spring and summer) to the number of four or five per sample. *Isotoma minor*, probably a holarctic species, was twice found between fifteen and thirty centimeters in June. *Friesia mirabilis*, *Isotoma notabilis*, *Achorutes (Hypogastrura) armatus*, and a *Zenyllodes* were not found otherwise. Corresponding and closely related species occur in our own region. Volz's thirteen lots average five individuals per cubic inches taken from six to thirteen inches deep. This small number of samples showed no population decrease with depth. Jacot (67) found 144 springtails in a square foot sample of an 80-year-old old-field woodland, between one to four inches deep, 28 in the next three inches and 16 between 11 and 13 inches deep in the Appalachians. The smallest sample with the eight specimens was from a grass bald. *Proisotoma sepulchralis* (Folsom) occurs in great abundance on cadavers buried six feet deep (45). Thus it may be concluded that the mineral soil harbors a varied fauna of springtails probably to the depth of root penetration (8-15 feet or more). The number would be conditioned by the number of dead roots and rootlets, or dead animals (cadavers, mice, earthworms) occurring in the soil from place to place, the depth of the water table, and the incidence of dry spells.

Proturans

Yellow-tips occur as far north as the White Mountains. They may be encountered in the mineral soil in the south under thin litter or mull soil conditions. They have sucking mouth parts, but no one seems yet to have discovered their food. Jacot (67) obtained two specimens from ninety cubic inches of soil 11-13 inches deep under *Andropogon* sod of a bald, as well as an occasional individual 4-7 and 11-13 inches deep under wood-

land in the southern Appalachians. Their effect is similar to that of the Collembolans though not so intensive.

Campodeoidea

Japyx is not uncommon in mull soils of the southern states. Though more robust than Proturans it is so much less common as to have but negligible effect on the soil.

The Acarina (Microarthropods)

Mites are the most ubiquitous and numerous soil arthropods. Although minute, they make up in numbers what they lack in size. Most of them are saprophagous though many are predaceous and suctorial. Certain species are structurally modified to dig, much resembling moles in body-form and in development of anterior legs. Most (if not all) of the soil diggers have the anterior tarsi furnished with a stout curved spine which may be used as a pick.

In addition to the diggers, many of the litter species enter the mineral soil to oviposit. Other species eat out dead roots and rootlets, thus secondarily channeling the soil. They undoubtedly go as deep as plant rootlets (eight to fifteen or more feet), provided they do not encounter the water table. Although at least one species, found at a depth of thirteen inches in two localities, has never been found outside the mineral soil, most of the species enter the organic layers on occasion.

They are so numerous that most investigators have not endeavored to identify them or even to count them accurately. Jacot (67) has given specific data on a few trial samples from the southern Appalachians. He found 1008 saprophytic and suctorial mites in a square foot sample from an eighty-year-old old-field woodland, between eleven and thirteen inches.

There is no other specific data on the Acarina of the mineral soil of woodlands.

In brief, although this group comprises minute species, they are so generally distributed throughout the mineral soil and so well provided for digging and channeling the soil, that they are the most important group of soil microarthropods.

The Chelonethida (Microarthropods)

Pseudoscorpions are small, active subterranean predators, living mostly on Collembola. Chiefly a litter or subcortical group, they may hibernate in the soil. *Microbisium parvulum* is common in most forest soils, though mull soil harbors much larger numbers.

The Araneida

Spiders, especially minute species, although common in the litter, are not known to enter the mineral soil of woodlands to any extent. The few Lycosids which have developed the burrowing habit are too widely scattered on the forest floor to exert any notable effect. The drier soils, especially unwooded, harbor a more extensive population of fossorial spiders, which climax in the trap-door spiders.

All spiders are predaceous, with sucking mouth parts.

The Diplopoda

Millipedes are predominantly a soil and litter group. They are intensive soil channelers.

"Since moisture is the most important factor limiting the distribution of millipedes, moist, dense woodlands with much undergrowth are their optimum habitat. Here they are sheltered from the sun, they are provided with a copious supply of decaying vegetation for food, and they are provided with many retreats in which to transform (moult) and lay their eggs. In open woods with organically impoverished soils the millipede fauna is correspondingly reduced. Moreover woodlands strewn with stones and boulders

shelter a more extensive millipede fauna than woodlands of alluvial or flood plains. [It is easier to obtain millipedes by turning over stones (a convenient diurnal retreat) than to dig them out of their earthy retreats; for on the whole, they prefer sandy to the more compact soils.] The woodlands which are most favorable to millipedes have a definite stratum of underbrush or herbaceous plants, decaying tree trunks, branches and bark, thick moss mats, a deep leaf layer which gradually merges into pure humus. On all these decaying plant parts develop many large and small moulds and mushrooms which are browsed upon especially by the Ascosporeophora. Altitude limits distribution only as humidity, decaying vegetation and shelter decrease" (92, p. 15).

Certain species are quite local and form colonies in the most favorable situations; other species are fairly evenly distributed throughout their habitat. Romell (83) describes the influence of such a colony (*Fontaria*) on soil structure, and figures their excrement clumps. Bornebusch (7) found Julids strongly associated with mull soils, while Polydesmids seemed independent of soil types. Diem (35, p. 159) found species usually recorded as from under bark and stones, in the upper and middle soil layers especially when rich in humus. Soils poor in humus are inhabited by only certain species. It is evident that millipedes normally live in the soil but that on certain occasions they emerge and crawl about the litter, hiding under stones and bark at daylight. Diem found that the type of soil determined the specific population. He records three definite soil types: dry, shallow soil with slight humus content; damp, deep soil; damp to wet, mild humus of irrigated meadow. In a sample of alkaline soil (10 x 10 x 5 inches) from mixed woods he obtained 33 millipedes representing six species, while in a spruce wood sample he secured 60 specimens of two species. These were his richest woodland samples which show violent fluctuations in number of individuals and of species. Bornebusch obtained an average of six Julids

per sample of 1183 cubic inches of mull (maximum 12 and 13) and but one Polydesmid (maximum 4 and 5).

Many species are sensitive to agricultural and anthropic disturbances. Increasing dryness and cold induce them to go deeper into the soil. Some Julids are much more resistant to dryness than are most of the Polydesmids. Certain species prefer alkaline to acid soils. They are able to withstand immersion in water from half an hour to several hours—depending on the species and the amount of air in the water.

The eggs of some of the litter species are laid in the soil, enclosed in fecal matter. Evans (41) found that some species lay all their eggs in one nest while others lay a few eggs in each of several places. Some millipedes make their nests in concavities in the litter (as acorn cups), while others dig into the soil until they find a firm foundation, as a stone. Morse (74) records *Fontaria indianae* ovipositing in sand to two inches deep.

The food of Julids is predominantly decaying roots, wood, leaves, and faeces; certain species prefer fungi; some polydesmids will eat well-decayed animal matter. Many species ingest soil and mineral particles with their food, and this forms part of their faeces. Certain species of millipedes may feed on crop plants when the amount of organic matter and humus in the soil is depleted to the extent that the animals would exert more energy finding the humus than they can derive from it (9). A few genera have piercing suctorial mouthparts.

Since nearly all recorded observations on east American millipedes were made on surface animals, practically nothing is known of the habits of truly soil millipedes: in fact, I am unable to determine which are typical soil species and which are predominantly litter species. One

of the characteristics of the rather large Fontarias is their habit of migrating from one locality to another, often by the million (18). Brade-Birks (8) records similar migrations after a heavy rain following a drought.

To summarize: although the habits of millipedes, especially soil species, are but little known, these arthropods stand out as one of the important groups of soil animals, affecting soil structure by their burrowing habits. Though one species of the northeastern states is as large as a lead pencil the most generally distributed and most abundant are minute.

The Chilopoda

Centipedes are very active and much less local than millipedes. As they are carnivorous and predaceous, they wander more widely in quest of food than do the millipedes. Diem (35, p. 160) records Geophilidae mostly from depths of eight to sixteen inches. In general, he found (p. 161) Chilopods more frequently, to a certain depth, than other groups of soil animals (the mites and other minute forms not studied). It is difficult to obtain data on their distribution in the soil because of their speed and of the large number of immatures ('undeterminable'). Taking large samples should overcome these difficulties. Bornebusch found Lithobiids more abundant in mull soil, while Geophilids were common everywhere though more especially in raw humus, and very irregularly distributed; one of his samples ($\frac{1}{16}$ of a square meter—about a square foot) yielding fifty-two individuals. In a sample (10 x 10 x 5 inches) from mixed woods with alkaline soil, Diem obtained twenty-seven individuals, representing five species, while in a spruce sample from twice that depth he collected twenty of the minute *Scolopendrella notacantha*. These were his richest

woodland samples which show violent fluctuations in number of individuals and of species.

The Isopoda

Sowbugs (pillbugs) may occur locally in forest litter and possibly in the mineral soil. Bornebusch records them as common in oak mull at one locality only (out of 80 samples, 11 localities). They descend to hibernate, and probably to aestivate and escape drought generally.

The Mollusca

Land-snails (land-shells) are found in all woods which have not been heavily grazed, trampled, or burned. The majority of the species are minute (a few millimeters) though a common species has a shell nearly an inch in diameter. Some species are quite drought resistant. Populations cannot be sampled with the same technique as is used for the arthropods. Some ascend vegetation to feed on green tissues, some are found on dead wood, but most of them are found in or on the litter entering the soil to aestivate and hibernate and many to oviposit. Jacot (66) found five species in most old-field woodlands, including white pine plantations in the southern Appalachians. The number of individuals per square foot varied considerably (maximum : 28). Presumably at least that number enter the soil in the autumn. The number of species and individuals in mull (cove) litter was much greater. Bornebusch (7, p. 86) found four species (30-70 individuals per square meter) common in most deciduous litters. Alkaline regions support a much more abundant and varied molluscan population. Diem (35, p. 35) secured the greatest number of species (eleven) and specimens (seventy-four in a ten-inch-square sample) from a mixed wood with strongly alkaline humus soil.

Little disturbed mesophytic woodlands should yield at least a dozen species; old-field woodlands, four or five. The number of individuals varies considerably locally, depending on degree of shelter. There is very little detailed quantitative data in this field.

Thus the effect of mollusca in soil channeling is seasonal and varies considerably with site conditions—which limit the population.

The larger Oligochaeta

Earthworms are undisputedly the most important animals affecting soil structure and soil fertility in woodlands. They not only push mineral soil out over the organic horizons but draw down into the mineral soil a certain quantity of organic matter, thus acting as mixers in two ways. Worm castings are frequently so mixed with organic matter that they constitute a high grade soil for plants to grow in (82). Their channeling of the soil locally is exceeded by no other animals, for *Lumbricus terrestris* reaches depths of six to eight feet for hibernation and during droughts, and they occur to a density of ninety per square meter in woodlands (10-15). Wollmy (104) showed that earthworms greatly increase the pore volume in the soil, and thereby make it much easier for water to enter. It is chiefly in late autumn that they draw dead leaves into their burrows to line their nests, and for food. The leaf blades are softened by their emitted pancreatic secretion, and the petioles ejected as a midden pile about the mouth of their burrows. One is seldom aware of their presence as they are active above the surface at night and when it is damp and rainy (35, p. 153). They ingest earth for its contained humus and organic content. The amount of their castings is therefore in inverse proportion to the amount of

leaves injected. When thus feeding on the soil humus their burrowing activities are more or less continuous. The humus is also used to line their burrows. They function as planters of maple trees by drawing maple keys into their burrows to feed on the key wings (86). Diem (35, p. 152), working in the Swiss mountains, found earthworms almost exclusively in the upper three inches of soil and working horizontally. Large numbers are often found dead on the soil surface after heavy rains. This phenomenon is explained by Merker (72, 73) as follows:

"Rainwater may lose its oxygen content in a few hours in the soil. The air of the burrows and other crevices of the soil is, therefore, replaced after a heavy fall of rain by deoxygenated water, and a zone of air-hunger for the inhabitants of the soil will be produced. The worms will evade this oxygen hunger by going deeper; if however, they cannot go further down, they will come to the surface, and will then wander about exposed to daylight. Daylight is intensely harmful to them because of the ultraviolet rays, so that, even in dull weather they will in two or three hours be paralyzed to such a degree that they can scarcely crawl" (86, p. 368).

Dry periods are passed in a state of suspended animation (anabiosis) deep in the soil. Hensen (60) found that half the humus lined burrows were used by plant roots to grow deeper. Diem (35, p. 153) found that the worms almost always avoid soil with a dry top layer, as also soils which are subject to great fluctuations in moisture content in the upper six inches. In fact he found that the soil condition below six inches does not affect the worms. It is the upper six inches which are critical. Neither slope nor exposure affect distribution provided the upper six inches of soil are otherwise favorable (35, p. 154). This does not apply to *Lumbricus terrestris*. Vegetation influences earthworms in so far as the amount of cover affects moisture conditions and its alkalinity.

In the northeastern states the indigenous earthworms are found chiefly south of the glaciated area. The earthworms of New England and New York are often species introduced from Europe. For example, the largest species is *Lumbricus terrestris* so carefully studied by Charles Darwin (32). The spread of this worm throughout our woodlands is not only slow but erratic, because it depends to such a large extent on artificial factors. The fisherman has done much to spread this worm along water courses by dumping his canfull at the end of the day and by throwing out small ones along his course. Farmers have aided by transplanting shrubs and plants from one farm to another, and by throwing garden thinnings across the road. Since the cocoons are deposited under the soil surface (and contain few embryos, often only one) (86, p. 662) they would not be transported on man's boots or cattle's hooves. Some undoubtedly have been transplanted in freshly dug bags of potatoes and other such products—especially on days of high atmospheric humidity. Suffice it to say that although this largest species is now found throughout New England and New York in favorable localities, it is very local. It becomes sexually mature in one year and lives five to six years (86).

A common European species (*Allolobophora longa*) lives from five to ten years, while the little European *Eisenia foetida* of manure and compost, and mouldering wood, lives three to four and a half years.

I have found what appears to be *Lumbricus terrestris* in fairly dense colonies under oak woods, northern hardwoods, and tulip-poplar coves in New England, and in smaller numbers under old-field spruce stands in alkaline soils, and at the edges of swamps under spruce and arborvitae over limestone. It is difficult to find poplar stands along streams without

this worm. It is intolerant of physiologically dry, highly acid soils with little or no humus. Calcium salts are necessary to replace the loss in the calciferous glands. These salts may be obtained from the deeper soil when overlain by an acid humus. A constantly high water table, or a water table high most of the year is unsuited to *L. terrestris*. Ground fires at night (when the worms are outside their burrows) would aid locally in their extermination. Orieux (77) states that they wander at the rate of 0.2 meters (their own length) per minute.

Some species of earthworms are typical litter dwellers or live under bark of old or dead trees and fallen branches (76). The effect of such species on the soil is much more limited than is that of the truly soil species. Bornebusch (7, p. 88 f.) found *Lumbricus rubellus* and *Allolobophora turgida* in beech woods; very few *L. terrestris*. He also found *Dendrobaena octoedra* in all raw humus soils and under a variety of conditions which excluded other species. Ribaucourt and Combault (82) relate how it lives in the moss on the rocks of high mountains and assiduously gathers the leaves carried by the wind, dragging them into their retreats to devour them, and forming mull in unpropitious localities. In Denmark (7, p. 95) it is of the utmost importance, being in most places the only species of earthworm living in raw humus soil. *Dendrobaena arborea* is also found active in forest soil (7, p. 94). *Eisenia rosea* is quite common in rich, clayey forest soil. In winter and the dry periods of summer, it may be found rolled up like a small pink ball at the lower boundary of the mould (7, p. 96). Bornebusch regards *Allolobophora turgida* as the most important (because the most abundant) species of earthworm in mull soils of Denmark, of sandy as well as of clayey texture. It lives in the mully topsoil,

directly under the leaf layer, but never in it. *Allolobophora trapezoides* replaces it further south in Europe. *Allolobophora longa* closely resembles *Lumbricus terrestris* in appearance and habits. *Allolobophora chlorotica* is most commonly found in clayey soil in the forest. *Lumbricus rubellus* he regards as one of the most important species of Danish forests, being one of the most adaptive as to mully sites. It was found in great numbers in beech raw humus, and also occurred in oak scrub and in coniferous plantations on the heaths. Although *L. terrestris* is much more choosy of sites, its work is of far greater importance than *L. rubellus* because of its size and the depth of its burrows. Diem (35, p. 38) records *Eisenia rosea* and *Allolobophora aporata* from spruce soil on limestone and *Octolasion lacteum* from spruce with no lime.

In little Denmark there are nineteen species of earthworms, most of them found in woodlands but under different conditions of soil, humidity, and humus content. In favorable localities Bornebusch (7, p. 100) got 358 and 254 worms representing nine species from a square meter of soil (depth not stated). On page 103 he then lists the worms found in eight different types of woodland soil. Friend (49, p. 15) lists thirty-seven species of Lumbricidae from the British Isles. Olson (76) records twenty-two species from Ohio, ten of them common to Denmark. Four useful Danish species, including the very tolerant *Dendrobaena octoedra*, are not recorded from Ohio. This suggests the introduction into America of useful forest species not yet found here. Since the earthworm population of New England and New York is one of chance introduction—(1) postglacial southern species, (2) European—there is a splendid opportunity to greatly improve our forest soils by introducing desirable species in

any forest or woodland tract where the soil condition has deteriorated through abuse or careless management. Some species are peregrine, others are sedentary.

The smaller Oligochaeta

The pot-worms (Enchytraeidae) are minute whitish worms able to live under a much greater variety of conditions than the Lumbricidae (earthworms). Population density, number per unit area, varies from none to thousands per square meter. They abound in the upper three inches of soil, especially about plant roots, wherever the humidity is fairly constant. Dry soils, cold soils, or soils with great variations in humidity strongly limit the numbers. Alkaline soils, rich in humus, are the most favorable (35, p. 148). Certain species are, however, xerophile (16). Diem secured 5504 individuals in a square meter of soil under spruce on limestone. Bretscher (16) obtained 8000 per square meter in soil of pine woods (without herbaceous cover); they were chiefly in the needle litter. I have found an average of a dozen per square foot in the litter layer of spruce woods.

Their food consists chiefly of plant detritus along with a certain amount of mineral particles (35, p. 149). They divide the earth and humus more finely than do the larger worms (68). Some feed on nematodes by excretion of digestive enzymes. Thus they aggregate about nematode infested plants (below ground) (86, p. 646).

It is difficult to gauge the value of these minute worms, or their effect on soil fertility and soil channeling. Too little is at present known about their habits, and their numbers, and they seem too insignificant to have much influence. However, it must be remembered that they are much more tolerant than the Lumbricidae, and that they make up in

numbers what they lack in size. We grossly underrate what does not loom large before our eyes. The Enchytraeidae should dominate the interest of several American investigators.

The Nematoda

The thread-worms are the smallest and most abundant of free-living soil worms. Since they have to be collected and studied by special methods they are very little studied unless they become of economic importance by attacking plants.

"Notwithstanding the enormous number of nematodes existing in every acre of arable soil, the actual volume and weight of the material composing the nematodes is relatively small. We cannot yet positively assert that they assist materially in the fertilization of the soil; it is, however, easily conceivable, in fact, there is a certain amount of evidence for the idea, that, indirectly, some species may be of considerable importance in maintaining or assisting to maintain a fertile condition."

"Though nematodes are small they are scattered through the soil in countless myriads in such a way that they must constitute an important mechanical factor. From the time they are hatched until death ensues, nematodes seem to be in constant motion. There is no evidence that they sleep. Such active organisms, existing as they do in every acre of arable soil in thousands of millions, must exert a more or less powerful mechanical influence" (26).

The nematode fauna of forest soils is almost unknown. Diem (35, p. 142) found them in the upper twelve to sixteen inches, in soils that were not too dry or that did not vary too intensely in humidity. Heavy, cold, damp clay soils and damp forest humus are not particularly favorable. Under all these conditions plant roots seem to be one of the most important factors.

RETROSPECT

The foregoing review yields the following generalizations:

1. There is an appalling dearth of knowledge both qualitative and quantita-

tive concerning the invertebrates which inhabit mesophytic woodland soils of the northeastern United States, or of forest soils in general. Our knowledge of the fauna of *forest* soils, especially quantitative, is more meager than is that of other culture types.

2. Much of our knowledge of soil animals is not specific enough to be of real value for culture or control purposes.

3. Animals may affect soil favorably (earthworms, millipedes, microarthropods) or unfavorably (social ungulates, social rodents).

4. Due to changes in culture types, especially plowing, much of our woodland does not harbor an adequate or balanced soil population.

5. Man may be unable to control volant animals, but the most important groups of soil animals are nonvolant (earthworms, millipedes, mites), have been severely localized, and are limited in dispersal by many man-made barriers.

6. Certain groups affect soil intensively; very locally, or intermittently (higher insects), while other groups exert a constant, general effect (earthworms, microarthropods).

7. Many insignificant forest animals, like woodchucks, voles, earthworms and mites are beneficial soil animals.

8. Many species of animals (mammals, burrowing birds, toads, insects) are important soil benefactors over a period of years, collectively and with cumulative effect.

9. Soil activity may be increased by encouraging ample growth of food plants of desirable soil-digging animals (especially such insects as Lepidoptera, root aphids). Certain insignificant trees and plants are important in initiating and maintaining good soil conditions through their effect in sweetening the upper layers

(poplar, tulip tree, ash) and in intensive, ephemeral root penetration (annuals).

10. Forest management will yield highest results when a long time view-point especially of humble species, is entertained.

11. Burrowing animals dig winter burrows deeper with increasing latitude.

INTERRELATIONS

A square-foot sample of long undisturbed, unburned humus taken from an acre of spruce woodland of northern New Hampshire yields as many as two hundred species of arthropods, without including the one hundred to two hundred species of arthropods which are so thinly sprinkled as to be missed by the sole square-foot sample. All the animals of a square mile of long undisturbed, unburned forest floor thus total well over four hundred species, without including such widely spaced species as the deer, bear, red-shouldered hawk, and rattlesnake. Increase in area of sample increases number of species (without including new habitats) due to mobility, colonial nature, and rarity (localness) of certain species. The interrelations of such a complex are difficult to visualize, especially when we are ignorant of the food habits of many of the species. A detailed review of interrelations is therefore impossible at the present time. However, certain general aspects are pertinent.

THE STRUCTURE OF AN ANIMAL POPULATION

To understand the structure of a population of animals one must understand the structure of the plant formation encompassing it. All major anemophorous trees are life forms capable of thriving independently of other life forms. When living crown to crown to form a continuous canopy (either unspecific or pluri-specific) they form a *forest formation*

(96, p. 139). The forest formation affords greater shelter and food supply to smaller species of plants and to animals than does any other formation (parkland, scrub, prairie, desert). The amount of shelter thus afforded is affected by intensity of wind action and of shade, and their concomittent factors (97, p. 268). The complexity of the forest formation is due to the size of the dominant life form—the tree. The kind or number of species of major (dominant) trees to a large extent determines the structure of the forest formation (96).

The minor structural units of the forest formation are the layers formed by the various plant forms represented, as: minor trees, shrubs, minor shrubs, herbs, mosses, lichens, algae, and organic debris (96, p. 330-331). Layers (strata) may be horizontal, vertical or oblique; plane, cylindrical or conic—depending on the form of the substratum.

The species of plants making up strata are of *sociological* importance only as they affect, or are affected by, other species of the formation. In such an agglomeration certain species are dependent on others or the effects produced by others, while some are independent, that is, capable of growing elsewhere, as in other formations (e.g. parkland, scrub, shrub desert, prairie, steppe). Species unable to live outside of the one formation or association are narrow (dependents); the others are wide (independents). To understand the structure of a formation *vital* relations should be determined. Much ecological work has been descriptive and quantitative, with little effort made to determine which species are dependents or independents.

Food Relations

All animals depend directly or indirectly on vegetation for nourishment and there-

fore existence. Hence animals do not form formations in the same sense as do the plants. They may be aggregated (for various reasons) to form populations or herds and colonies—unispecific or plurispecific. To postulate animal formations or associations in woodlands is a false concept. Similarly, a fauna is not a vital community, but a group of animals brought together by shelter, food, population pressures, migration and such historical factors as land bridges, winds, floods, fires. Each species in the fauna is not vitally connected with all the others. Many are "associates" by juxtaposition, proximity, common food. Some live just as well in another association or formation.

Animals dependent on primary foods (green plants) are *primary animals*—herbivores (phytophages). Saprophages are *low primaries*. Animals dependent upon primary animals are *secondary animals*, as predators and parasites, which may be tertiary, quarternary, etc. A hawk that feeds on snakes that feed on batrachians that feed on arthropods (of various feeding habits), is a quarternary or quinternary predator—better say a *remote predator* (remote from the primary supply). Fungivores, necrophages, and coprophages are *low secondaries*.

The various primary animals (phytophages) of a formation are often independent of each other. Each may depend on different plants or plant products of the formation. For example deer and rabbits are quite independent of each other, but both are present in the forest because of the advantages offered by the forest. They do not even compete, since the one is a high browser and the other a low browser. They are related to each other merely as *members* of the forest formation. Phytophagous animals are motile interstitials of vegetation, center-

ing about their nests (territory) or feeding grounds.

Primary animals feeding on the same food are *mess-mates*, sometimes *competitors*. For example, the elm-leaf beetle (*Galerucella xanthomelaena*), the elm sawfly (*Cimbex americana*), the elm sawfly miner (*Kaliotenus ulmi*) (61), and the following caterpillars are all *associates* of the elm because they feed on the elm (in the same geographical region): *Nepticula apicalbella* mines upper side of leaves (Ohio), *Lithocolletis argentinetella* mines under side of leaves, *L. ulmella* mines upper side of leaves, *Coleophora limosipennella* eats the leaves, *Helice constrictella* feeds on the leaves, webbing the under surface, *Anchylopera fuscociliana* (leaf folder and eater), *Tetralopha asperatella* (leaf roller and eater), *Canarsia ulmiarrosorella* eats the leaves (forming a silk nest between the leaves) (47), and others. All these and many more are *members* of the elm tree association, and since they all feed on elm leaves at the same time of year, they are *potential* mess-mates, though seldom found on the same leaf at the same time, thus rarely *competitors*. The caterpillar, *Argyresthia undulatella*, feeds on the bast of the larger branches and trunk of the elm. It is thus an *associate* of the elm, and a *member* of the elm association but it has no vital (sociological) relation to the leaf feeders. Its relation to them is spacial—one of juxtaposition. On the forest floor many species of animals feed on faeces, many on dead leaves, and many on fungal mycelia. However, there often is a succession of species through degrees of reduction or decay (2, fig. 17, p. 154). Hence, mess-mates are a common phenomenon, but their mateship is sociologically fortuitious, often a result of historical or phylogenetic factors.

To catch a lot of animals in a number of net sweeps or in a cylinder and classify

them on the basis of numbers of individuals of each species as dominant and subdominants is a laboratory concept. Sweeping the foliage of an elm tree would give very different dominants and subdominants from tree to tree, from month to month, and from year to year without indicating interrelations—the structure of the population of the elm tree, much less the structure of an elm community. Thus to understand an association or a fauna, food habits are one of the most important interrelations (and one of primary economic importance to man).

Primary animals are to be found among all phylogenetic categories of forest floor animals, but many of them also take in small amounts of secondary foods. In grouping animals by their food relations the major food is understood, for this will indicate the major effect of each species in the association. Even as small a category as a phylogenetic family of animals will include primary and secondary feeders. For example, some ants (Myrmicidae) are graminivorous (*Pheidole* and *Tetramorium*), some fungivorous (*Atta*), and some are carnivorous (various) (100). Hence it is imperative to study the feeding habits of each in order to determine its sociological place in the community. This is just as true of Protozoa as of higher animals (85, p. 3, 3). Specificity is of considerable importance in evaluating a species. Many predators are wide (euryphagous) in their feeding habits, while many phytophages are restricted to one food (stenophagous or monophagous).

Food habits are conditioned by the size of the animal and its type of mouth parts, as well as by its internal conditions. The diagram on the following page should illustrate this point.

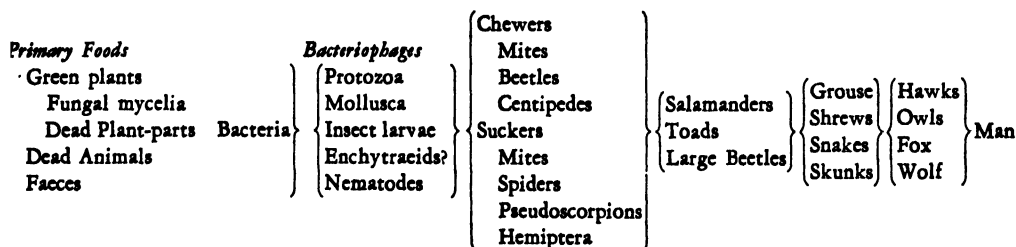
The following groups of saprophagous animals (with chewing mouth parts—a primitive condition) have developed

genera with sucking mouth parts: millipedes, springtails, Oribatid mites, Tyroglyphid mites (*Histiostoma*), Raphignathid mites, Nematodes. Thus there is a definite factor in animal tissues which, by causing attenuation of mouth parts, determines feeding habits.

Nesting Site

Nesting site is another important interrelation. This means the place where the eggs are laid. Place of hibernation, aestivation, pupation, moult, are not necessarily included. The nesting site is often the place where the immature feeds or where its food is brought. Hence food and nesting site may be closely re-

lated. Such numbers may fluctuate violently from year to year, or month to month, at times from hour to hour, depending on migrations, epidemics, hatching or transformation dates, and other factors. To set up an ecological classification based on numbers may be spectacular (a picture) but it is not vital. Should ecological studies comprise ephemeral pictographs or should they present vital relations? (It is much more difficult to analyze feeding habits and work out life cycles than to collect a net or can full of specimens and send them to specialists for determination. The former calls for a biologist, the second for a technician or clerk.)



lated. The nesting and egg-laying habits of all species of an association should be known. In fact no animal can be properly evaluated as to its influence in an association until its entire life history, including its predators, parasites, diseases and competitors and their incidence, is known. This is a fundamental ecological principle. It is as true of Protozoa as of higher animals (85, pp. 2, 3).

In America the animals of an association are often ecologically classified on the basis of relative numbers—dominants, subdominants, etc. Recent work in ecology has shown that *numbers* of individuals of a primary animal is an index of available shelter and of available food (37-40). The relative numbers of each species gives a picture of the association

Duration

The degree of dependance on the association (forest or layer) is expressed by the suffixes -bionts, -philes, -xenes. The soil and litter fauna (the geenton) is a practical unit, a layer of the forest, grassland or desert. It is one layer (one reel) of a complete picture. Its *geobionts* (67, p. 377; 48, p. 21) are directly dependent upon plant roots (or other underground parts), decaying plant parts, fungi, faeces, or other animals, for their *full* time maintenance and well-being. Those animals which spend *part* of their lives in the soil, either as egg or immature stages, or as adults, for hibernation, aestivation, oviposition, nidification, and feed outside, are *geophiles* (67, 48). Strays are *geoxenes*.

Collectively, they are *geocols*. Geobionts able to live in the soil layer of another plant association (parkland, scrub, grassland) are *wides*. To classify each species of animal under such heads as food relations, effect on the associate or the habitat (trampler, dunger, borer, miner, chewer, sucker) and duration, tersely presents data on which can be based the place and the effect of that species in the association. The relative numbers of a species, under certain conditions, might indicate the intensity of its effect.

Daily Vertical Migrations

Volz (93) found that most of the pigmentless (eyeless) springtails of the soil occurred at the lower depths while the pigmented, patterned, fully-eyed species occurred chiefly in the litter. Collecting in spruce woodlands of the White Mountains (N. H.) in the early morning, when the ground was still in deep shadow and the litter still dew wet, I found that most of the pigmentless species were in the upper layers of spruce litter in great abundance while *some* of the pigmented species (especially *Achorutes armatus* and *A. nivicolus*) were lower down. It is probable these animals migrate to the lower layers as the rising sun dries out the upper layers, and back to the upper layers as the sun sets and the forest floor becomes cool and moist (dewy). Thus the lower layers would act as a retreat during periods of drought for many of the springtails. These daily migrations would account in part for the variation in numbers per sample of litter.

Holdhaus (63) reports such daily vertical migrations of the soil fauna in the upper alpine zone under the influence of the sun's rays. In the forest he found the fauna of the topsoil decreased somewhat in numbers on hot days, but there was no general migration. Beetles were found

more numerous at night than by day, but he has no proof that this was due to migration to lower soil horizons. Volz (93) found no marked daily migration of springtails in the flood plain (deciduous) woodland. This he attributes to the leaf layer which remains relatively saturated with water even in the summer [and German summers are apt to be pretty wet]. In the pine forest soil, however, he found evidence of migration from the litter into the raw humus at least during warm dry weather. This he attributes (in part) to the great pore space (88 per cent) of the raw humus.

In brief, therefore, one may conclude that in dry woodlands, in a relatively dry climate, there may be general migrations, but in moist woodlands (especially deciduous) in moist climates there would be practically no daily migrations. In other words, daily vertical migrations of *Collembola* (and other soil microarthropods) seem to be chiefly conditioned by the degree of change in the humidity of the litter layer, due to degree of solar radiation and degree of dew "fall" at night.

Another factor influencing such a migration would be the nature of the fauna itself. This has been brought out by Marie Hammer (57) in her studies of the soil fauna of Greenland. In brief, irrespective of vegetative cover type (as found in Greenland), if the lower soil horizons are constantly moist, they harbor a moisture sensitive fauna. If the lower soil layers are apt to dry out considerably during some part of the growing season, only dry tolerant species are found. Such species would not be moved to migrate by slight daily changes in humidity. It is the *minimum* condition during the year—and probably also over a cycle of years—which determines the nature of the population, as regards sensitivity and

indifference. Therefore, what actually occurs at any one locality or in any one type of woodland would have to be determined by an analysis of the population at that place and in that forest type.

Daily vertical migrations in the mineral soil would also depend to a certain extent on the depth and character of the overlying organic (litter and humus) layers, and degree of plant shelter.

Volz is satisfied that frost causes no marked changes in the vertical distribution of Collembola, though there seems to be vertical migrations of a few inches (two to four) with certain species, notably such as *Onychiurus*.

Even though the forest floor and especially the underlying mineral soil is an unusually protected and stable environment, there is wide variation of moisture conditions in the upper two inches due to differences in crown density, number of strata of vegetation (openness of the stand), degree of regeneration, degree of fluctuation versus constancy of water table level, distribution of rainfall through the year, especially through the growing season, history of the stand, and degree of pasturage (trampling). Thus Volz should not find evidence of migration between the lower layers, but considerable evidence in the upper two or three inches through every twenty-four hours. The sun shining on one spot for a half hour should cause considerable migration as the litter of that spot warms up under the sun's direct rays. The migration would be particularly active along the advancing periphery of the sunspot. Hence vertical migration may be an extremely local phenomenon, ephemeral and daily. This phenomenon makes deeper samples imperative.

Ingress

A group of animals found in the soil, but not soil animals, are those inhabiting

the nests of the burrowing vertebrates. These microcaverns shelter a host of beetles and flies ecologically known as *pholeocoles*. This fauna comprises parasites, commensals, riders of the hosts, and saprophages on nesting material and food refuse, coprophages, mycophages, and predators, parasites and commensals on the saprophages, coprophages and mycophages (42). Those species which enter through the burrow of the host, and which, therefore, do not affect soil structure, are not geocoles.

The same may be said of many myrmecocoles, termitocoles, and inhabitants of the nests of other soil insects (especially bees and wasps).

Competitors and Tolerances

This is as yet a laboratory subject. Very few examples are known in nature. Closely related geocoles live side by side apparently on the same food. They have one great advantage over their laboratory relations—they and the factors of their environment (as circulation) are not limited by the glass walls of a small jar.

CONTROL

The foregoing review would be economically sterile without at least a glance at the social significance of the observed phenomena. Nature is haphazard in some of its end results. Time is of no consideration. Man can hasten natural processes by introducing absent desirables. He has the biota of nearly the entire length of a life zone to choose from.

From the recreational viewpoint, the more wild life we find in our woodlands the more interesting the woodlands become—provided the public discards its childhood fears, and learns what animals (and plants) are really injurious. In New England they are so rare that thirty years of woodland wanderings have not lead me to one of them (poison ivy ex-

cepted). A fundamental principle then is to eliminate nothing that is not positively injurious to man or his well-managed enterprises. Corollary: Control the numbers of only those species which are disagreeable to man when too numerous.

From the point of view of silviculture (the wood crop) the problem is much more complex. After decades of experience the forester has come to realize that mixed stands are better than pure stands—over a long period of time, as for national and state forests. Yet some foresters go about with murderous thoughts for poplars, tulip trees and other lumber-poor species, species albeit which are the most desirable to earthworms, millipedes, molluscs, bacteria and other highly desirable soil animals. In fact, an entirely neglected phase of silviculture is (1) the encouragement of herbs, shrubs and minor trees, the litter of which will sweeten or reduce the acidity of the litter and humus, and thereby generate better soil, (2) the encouragement of herbaceous plants which will annually permeate the soil with dying rootlets which then may be eaten out and leave in their place a divaricating system of water conduits.

Channeling

A compacted soil absorbs but little rain-water which consequently runs over the surface, swells the brooks and streams and causes floods. A soil full of channels takes in the rain-water and distributes it underground. This entering water carries with it into the soil, finely divided organic particles of the litter layer. Thus one of the most desirable soil conditions is a high degree of channeling.

Channeling is brought about in two ways, (1) by burrowing animals, (2) by animals which eat out dead and decaying rootlets (and roots). Every time an annual plant dies its divaricating root

system offers a potential irrigation system to the surrounding soil. Hence a carpet of annual plants plus an association of dead-root eating animals are two essentials to good soil channeling.

Any animals channeling the soil by burrowing about in it are desirable, if not otherwise injurious. Some of the damage done by leaf eaters is offset, in the case of species which pupate in the soil, by their burrowing activities. If these species feed on the humbler plants their effect is "all to the good." Some species prefer humbler plants to oaks. A varied flora is thus of greater advantage to the soil than a restricted flora. Grazing of woodlands destroys the herbaceous flora and compacts the soil by trampling. All plants which offer food to insects hibernating or pupating in the soil should be encouraged (except poison ivy).

Mixing

When leaves fall to the ground they become the hosts of various fungi which reduce their contents and make their tissues soft (rotten). In this stage many minute animals are able to feed upon them and further reduce their tissues to minute particles (faeces). If the soil is compacted, these organic crumbs are washed into the brooks and streams and accumulate on and beyond the continental shelf. Far better is it to have this organic residue mixed into the mineral soil. This process is carried on by earthworms, ants, millipedes and some of the mammals, not to mention a host of miscellaneous insects. Not only do these animals push mineral soil out onto the organic layers but some of them draw down into the mineral soil, dead leaves and other organic residues. All such animals should be encouraged—introduced where absent. Many mixers cannot live under an acid litter layer. Therefore all plants, the decaying litter of which tends to alkalinate the litter,

should be encouraged and introduced when absent.

Restocking

Glaciation and forest fires have greatly reduced faunas locally. Such depopulated areas can be restocked by man if done intelligently and with a knowledge of the requirements of the desirable plants and animals. One of our best soil improvers is the European earthworm, called the angle worm or night crawler (*Lumbricus terrestris*). It is an example of the great good obtainable by introducing desirable aliens.

There are, however, some soils which do not favor *L. terrestris*, but they allow *Dendrobaena octaedra* to improve them to such an extent that two or three other species (*L. rubellus*, *L. castaneus* and *D. arborea*) may become established. These species will further improve the soil condition, especially as to humus content, so that *Allolobophora turgida* is enabled to thrive. In this way the soil condition may be built up, at least as to humus content, until it becomes suited to the most desirable—*L. terrestris*. This sequence or succession is outlined by Bornebusch on page 103 (7). It should be noted that mull soil is produced by other worms besides *L. terrestris*. One hears so much about *L. terrestris* because of Darwin's volume, and because its midden piles are spectacular. It is not necessary to confine ourselves to European worms. There undoubtedly are North American species south of the glaciated area which chance has not yet introduced northward. Finally, there are earthworms in north-eastern Asia, Argentina and possibly south Africa which would bear investigation as possible allies in soil improvement. We are so ignorant in this field, that we do not even have a serious list of the earthworms of New England (51).

However, earthworms are not the only factor in soil improvement. Elimination of trampling and over-grazing by cows or sheep; encouragement of underbrush and reproduction, especially around the edge of the tract, to reduce dessication by wind action; encouragement of shrubs forming alkaline litter rather than acid; encouragement of under-trees forming alkaline litter; starting a stand with a sprinkling of trees forming alkaline litter (as poplars), but which will later drop out as the desirable trees grow larger; and other such silvicultural management, coupled with the early introduction of certain millipedes, earthworms, and soil-mites, should insure good soil conditions *from the start*. Earthworms and other desirable soil animals as well as sociologically desirable woodland plants should be introduced at the *inception* of a plantation to enable the animals to start litter reduction and humus incorporation before the litter becomes acid. Romell (84, bottom of p. 13) describes how once the soil has been started on the alkaline side, the soil fauna maintain it, but once it gets started on the acid side it will become more and more acid, for the processes involved are cumulative.

Once the fauna becomes established, it will maintain itself by the way it conditions the soil, and by keeping ahead of litter accumulation, especially if the stand is not allowed to become too dense. In this way, by the intelligent use of the most humble plants and animals, which work day and night, and for nothing, soil may be permanently established at its optimum condition of moisture and fertility. Control, especially initial control, is of cardinal importance. Upkeep is barely necessary since the processes are cumulative and effective in the aggregate.

SUMMARY

Soil improvement must take into consideration the soil fauna, the surface animals, and the vegetation in its entirety, for many species in the forest have their particular effect, their contribution, in one direction or another. There is succession in the soil fauna, as there is succession in the flora. Nature's course is haphazard; man can bring about optimum conditions rapidly by enlightened management. He can, not only direct, but

hasten nature's processes: (1) by eliminating chance and (2) by using short cuts, and especially (3) by giving the forest complex the right start. At present we have but fragmentary knowledge of the desirable species at hand, and almost no knowledge of the species available from other areas.

[Because of the untimely and lamented death of Dr. Arthur Paul Jacot, while this paper was in the press, the revision and extension of the following bibliography that he had intended to make, could not be accomplished. *Editor.*]

LIST OF LITERATURE

1. ABBOTT, CYRIL E. 1938. The development and general biology of *Crotophaga villosus* Grew. *Jour. N. Y. Ent. Soc.*, 46: 49-52, 1 pl.
2. ADAMS, CHARLES C. 1915 (Sept.). An Ecological Study of Prairie and Forest Invertebrates. *Bull. Ill. State Lab. Nat. Hist.*, 11 (2), 280 pp., 63 pls., 17 txt. figs.
3. ALEXANDER, CHARLES P. 1920 (June). The Crane-flies of New York. II. Biology and Phylogeny. *Cornell Univ. Agr. Exp. Stat., Mem.* 38, 1133 pp., 97 pls.
4. BANKS, NATHAN. 1929. A classification of the Psocidae. *Psyche*, 36: 323-325.
5. BISHOPP, F. C., J. D. MITCHELL, AND D. C. PARMAN. 1922 (Jan.). Screw-worms and Other Maggots Affecting Animals. *U. S. D. A. Farmers Bull.* 857, 19 pp.
6. BLAKE, IRVING HILL. 1927 (May 21). A Comparison of the Animal Communities of Coniferous and Deciduous Forests. *Ill. Biol. Monog.*, 10 (4): 148 pp., 16 pls.
7. BORNEBUCH, C. H. 1930 (April 1). The Fauna of Forest Soil. *Det forstlige Forsogsvaesen*, 11: 225 pp., 28 pls., 7 txt. figs.
8. BRADY-BIRKE, S. GRAHAM. 1922 (Feb.). Notes on Myriapoda XXVII. Wandering millipedes. *Ann. Mag. Nat. Hist.*, ser. 9, 9: 208-212.
9. —. 1929 (July). Notes on the Myriapoda XXXIII. The economic status of the Diplopoda and Chilopoda and their allies. *Jour. Southeastern Agr. Coll., Wye, Kent*, Nos. 26, 27; pp. 178-216, 102-146, 58 figs.
10. BRETSCHER, K. 1895-6. Die Oligochaeten von Zürich, in systematischer und biologischer Hinsicht. *Rev. Suisse Zool.*, Bd. 3.
11. BRETSCHER, K. 1899. Beitrag zur Kenntnis der Oligochaeten-fauna der Schweiz. *Ibid.*, Bd. 6.
12. —. 1900a. Ueber die Verbreitungsverhältnisse der Lumbriciden in der Schweiz. *Biolog. Zentralblatt*, Bd. 20.
13. —. 1900b. Mitteilungen über die Oligochaetenfauna der Schweiz. *Rev. Suisse Zool.*, Bd. 8.
14. —. 1900c. Südschweizerische Oligochaeten. *Ibid.*
15. —. 1900d. Zur Biologie der Regenwürmer. *Biolog. Zentralbl.*, Bd. 21.
16. —. 1904. Die Xerophilen Enchytraeiden der Schweiz. *Ibid.*, Bd. 24.
17. BREWSTER, WILLIAM. 1936. October Farm. *Boston*, 285 pp.
18. BROOKS, FRED E. 1919. A migrating army of millipedes. *Jour. Ec. Ent.*, 12: 462-464.
19. —. 1921 (Nov. 4). Walnut Husk-Maggot. *U. S. D. A. Bull.* 992, 8 pp., 4 pls.
20. —. 1922 (June 21). Curculios that Attack the Young Fruits and Shoots of Walnut and Hickory. *U. S. D. A. Bull.* 1066, 16 pp.
21. BURGESS, A. F., AND COLLINS, C. W. 1917 (July 25). The Genus *Calosoma*. *U. S. D. A. Bull.* 417, 124 pp., 19 pls.
22. BURROUGHS, JOHN. 1913. The Summit of the Years. *Boston*, 298 pp.
23. CHAPMAN, PAUL J. 1930 (Sept.-Dec.). Corrodentia of the United States of America; I. Suborder Isotecnomeria. *N. Y. Ent. Soc. Jour.*, 38: 219-403, pls. 12-21.
24. CHITTENDEN, F. H., AND NEALE F. HOWARD. 1917 (June 28). The Horse-Radish Flea-Beetle: Its Life History and Distribution. *U. S. D. A. Bull.* 535, 16 pp.

25. COBB, N. A. 1914. The North American free-living Nematodes. *Trans. Am. Micr. Soc.*, 33: 69.
26. —. 1915. Nematodes and Their Relationships. U. S. D. A. Yearbook for 1914, pp. 456-490.
27. COMSTOCK, J. H. AND ANNA BOTSFORD. 1916. A Manual of the Study of Insects. 701 pp., 797 figs.
28. CULVER, JULIAN J. 1919 (July 10). A Study of *Compilura concinnata*, etc. U. S. D. A. Bull. 766, 27 pp.
29. CURRAN, CHARLES H. 1934. The Families and Genera of North American Diptera. 512 pp., many figs.
30. CUTRIGHT, CLIFFORD R. 1925 (Sept.). Subterranean Aphids of Ohio. *Bull. Ohio Agr. Exp. Stat.*, No. 387, pp. 173-238, 6 pls.
31. DANIEL, DERRIL M. 1928 (Feb.). Biology and Control of the Blackberry Leaf-Miner. N. Y. State Agr. Exp. Stat. (Geneva), Tech. Bull. 133, 38 pp., 5 figs., 1 pl.
32. DARWIN, CHARLES. 1881. The Formation of Vegetable Mould through the Action of Worms, with Observations on their Habits. Murray, 326 pp., 15 figs.
33. DAVIS, JOHN J. 1917 (Dec.). The Corn-Root Aphid and Methods of Controlling It. U. S. D. A. Farmers Bull. 891, 12 pp., 5 figs.
34. —. 1919 (Feb.). Contributions to a knowledge of the natural enemies of *Phyllophaga*. Ill. Nat. Hist. Surv. Bull., 13: 53-138, pls. 3-15.
35. DIEM, KONRAD. 1903. Untersuchungen über die Bodenfauna in den Alpen. Dissertation: St. Gallen, 187 pp.
36. EATON, ELON HOWARD. 1914. Birds of New York. Part 2. 719 pp., 106 pls.
37. ERRINGTON, PAUL L. 1937. What is the meaning of predation? *Smith. Inst. Rpt.*, 1936, pp. 243-252.
38. —. 1937 (March). Winter carrying capacity of marginal ruffed grouse environment in north-central United States. *Canad. Field-Nat.*, 51: 31-34.
39. — AND F. N. HAMERSTROM. 1936 (June). The Northern Bob-White's Winter Territory. *Iowa State Agr. Exp. Stat., Research Bull.* 201, 443 pp., 26 figs.
40. —. 1937 (July). Evaluation of nesting losses and juvenile mortality of the ring-necked pheasant. *Jour. Wildlife Manag.*, 1: 3-20.
41. EVANS, T. J. 1910 (Sept.). Bionomical observations on some British millipedes. *Ann. Mag. Nat. Hist.*, ser. 8, 6: 284-291.
42. FALCOZ, LOUIS. 1914. Contribution à l'Étude de la Faune des Microcavernes, Faune des Terriers et des Nids. *Lyon*, 187 pp., 38 figs., 1 pl.
43. FALL, H. C. 1924 (Oct.). The blueberry leaf-beetle and some of its relatives. *Maine Agr. Exp. Stat. Bull.* 319, pp. 81-141.
44. FLEMING, W. E. AND BAKER, F. E. 1936. A method for estimating populations of larvae of Japanese beetles in the field. *Jour. Agr. Res.*, 53: 319-331.
45. FOLBOM, JUSTUS WATSON. 1902. Collembola of the grave. *Psyche*, 9: 363-367, illus.
46. FORBES, STEPHEN A. 1907 (Aug.). On the life history, habits, and economic relations of the white grubs and May beetles. Ill. Agr. Exp. Stat. Bull. 116, pp. 447-480.
47. FORBES, WM. T. M. 1923 (July). The Lepidoptera of New York and Neighboring States. *Cornell Univ. Agr. Exp. Stat., Mem.* 68, 729 pp., 439 figs.
48. FRENZEL, GERHARD. 1936. Untersuchungen über die Tierwelt des Wiesenbodens. Fischer, 130 pp., 8 figs.
49. FRIEND, HILDERIC. 1924. The Story of the British Annelids (Oligochaeta). London, 288 pp., 57 figs., 1 col. pl.
50. FRISCH, JOHN A. 1937. The life-history and habits of the digger wasp *Ammobia ichneumonea*. *Am. Midl. Nat.*, 18: 1043-1062.
51. GATES, GORDON E. 1929 (Sept. 13). The earthworm fauna of the United States. *Science*, 70: 266-267.
52. GHILAROV, M. S. 1937 (Dec.). The fauna of injurious soil insects of arable land. *Bull. Ent. Res.*, 28: 633-637.
53. GIBSON, EDMUND H. 1916 (June 9). The Corn and Cotton Wireworm in its Relation to Cereal and Forage Crops. U. S. D. A. Farmers Bull. 733, 7 pp.
54. GOSSARD, H. A., AND J. L. KING. 1918 (Sept.). The peach-tree borer. *Ohio Agr. Exp. Stat. Bull.* 329, pp. 53-87.
55. HAMILTON, CLYDE C. 1925. Studies on the Morphology, Taxonomy and Ecology of the Larvae of Holarctic Tiger Beetles (Family Cicindelidae). *Proc. U. S. Nat. Mus.*, 65 (17): 87 pp., 12 pls.
56. HAMILTON, WM. 1936 (Aug.). Seasonal food of skunks in New York. *Jour. Mam.*, 17: 240-246.
57. HAMMER, MARIE. 1937. A Quantitative and Qualitative Investigation of the Microfauna

- Communities of the Soil at Angmagssalik and in Mikis Fjord. *Mad. Grøn.*, 108 (2): 53 pp., 17 figs.
58. HATCH, EDITH M. 1912 (Dec.). Aphidae. *Ms. Agr. Exp. Stat. Bull.* 207, p. 448.
 59. HAYES, WM. P. 1918. Studies on the life-history of two Kansas Scarabaeidae (Coleoptera). *Jour. Ec. Ent.*, 11: 136-144.
 60. HENNEN, V. 1877. Die Thätigkeit des Regenwurms (*Lumbricus terrestris* L.) für die Fruchtbarkeit des Erdbodens. *Zeitschr. f. wissenschaftl. Zool.*, Bd. 28.
 61. HERRICK, GLENN W. 1935. Insect Enemies of Shade Trees. 417 pp.
 62. — AND C. H. HADLEY. 1916 (July). The lesser migratory locust. *Cornell Univ. Agr. Exp. Stat. Bull.* 378, pp. 11-12; 20-23.
 63. HOLDHAUS, KARL. 1912. Ueber die Abhängigkeit der Fauna vom Gestein. *Verh. intern. Zool. Kongr., Jena*, 8 (1910): 726-745.
 64. HOUSER, J. S. 1912 (Sept.). The wheat leaf-miner. *Ohio Agr. Exp. Stat. Bull.* 251, pp. 79-86.
 65. HYSLOP, J. A. 1915 (Jan. 27). Wireworms Attacking Cereal and Forage Crops. *U. S. D. A. Bull.* 156, 34 pp.
 66. JACOT, A. P. 1935 (Oct.). Molluscan populations of old growth forests and rewooded fields in the Asheville Basin of North Carolina. *Ecology*, 14: 603-605.
 67. —. 1936 (July). Soil structure and soil biology. *Ecology*, 17: 359-379, 3 figs.
 68. JÖRN, G. 1920. Zur Biologie und Anatomie einiger Enchytraeiden. *Vjschr. naturf. Ges., Zurich*, Bd. 65.
 69. LINDQUIST, ARTHUR W. 1934 (April). Notes on two *Vespula* nests from Kansas. *Jour. Ent. Soc., Kansas*, 7: 51-55.
 70. LOWE, V. H. 1898 (Dec.). Preliminary notes on the grape-vine flea-beetle. *N. Y. Agr. Exp. Stat. (Geneva), Bull.* 150, pp. 263-265, pls. 6-7.
 71. MARLATT, C. L. 1907 (July 18). The Periodical Cicada. *U. S. D. A. Bur. Ent., Bull.* 71, 181 pp., 68 figs.
 72. MERCKER, E. 1926. Die Empfindlichkeit feuchthäutiger Tiere im Lichte. *Zool. Jahrb., Allg. Zool.*, Bd. 42.
 73. —. 1926. Warum kommen Regenwürmer in Wasserlachen um und warum verlassen sie bei Regen ihre Wohnröhren? *Ibid.*
 74. MORSE, MAX. 1904 (May). Breeding habits of the Myriapod *Fontaria indianus*. *Ohio Nat.*, 4: 161-163.
 75. NEFEDOV, N. I. 1930. A quantitative study of the ant population of the Troitsk Forest-Steppe Reserve. *Bull. Inst. Rech. Biol. and Sta. Biol. Univ. Perm.*, 7: 259-291, 8 sets of quadrats.
 76. OLSON, HENRY W. 1928 (Nov.). The earthworms of Ohio. *Ohio Biol. Surv., Bull.* 17, pp. 47-90, 8 figs.
 77. ORIEUX, M. A. 1899. Les Vers de Terre. *Bull. Soc. Sci. nat. Ouest, Nantes*, T. 9.
 78. PARROTT, P. J. AND H. GLASGOW. 1916 (Dec.). The Leaf-Weevil. *N. Y. Agr. Exp. Stat. (Geneva), Tech. Bull.* 56, 24 pp.
 79. PEARSE, A. S. 1926. Animal Ecology. McGraw-Hill, 417 pp.
 80. PHILLIPS, W. J. 1909 (Nov. 30). The slender seed-corn ground-beetle. *U. S. D. A. Bur. Ent., Bull.* 85, pt. 2, pp. 13-28.
 81. RAU, PHIL. 1928 (June). Field studies in the behavior of the non-social wasps. *Trans. Acad. Sci., St. Louis*, 25: 325-341.
 82. RIBAUCCOURT, E., AND A. COMBAULT. 1907. Utilité des vers de terre en agriculture. *Bull. Soc. cent. forest., Belgique*.
 83. ROMELL, L. G. 1935 (Jan.). An example of Myriapods as mull formers. *Ecology*, 16: 67-71, 2 figs.
 84. —. 1935 (Feb.). Ecological Problems of the Humus Layer in the Forest. *Cornell Univ. Agric. Exp. Stat., Mem.* 170, 28 pp.
 85. SANDON, H. 1927. The Composition and Distribution of the Protozoan Fauna of the Soil. Oliver and Boyd, 237 pp., 6 pls., 3 charts.
 86. STEPHENSON, J. 1930. The Oligochaeta. Clarendon. 978 pp., 242 figs.
 87. STEWART, F. C. 1896 (Dec.). The cucumber flea-beetle as the cause of "pimply" potatoes. *N. Y. Agr. Exp. Stat. (Geneva), Bull.* 113, n.s., pp. 309-317, pl. 1.
 88. STONER, DAYTON. 1937 (Nov. 19). Three returns of a bank swallow. *Science*, 86: 469-470.
 89. TANLEY, A. G. 1923. Practical Plant Ecology. Dodd Mead, 228 pp., 15 figs.
 90. THORBAU, H. D. 1881. Early Spring in Massachusetts. Houghton, 354 pp.
 91. —. 1884. Summer. 382 pp.
 92. VERHOEFF, KARL W. (no date). Oberklasse: Progoncata. In: BROHMER, P., P. EHREMAN, G. ULMER. Die Tierwelt Mitteleuropas. Bd. 2, Lief. 3, 90 pp., 114 figs.
 93. VOLZ, PETER. 1934 (Dec. 8). Untersuchungen über Mikroschichtung der Fauna von Wald-

- böden. *Zool. Jahrb., Abt. Syst. Ost. Geog. Tiere*, 66(3/4): 153-290.
94. VORN, RALPH. 1934 (Dec. 31). Biologic investigations on the Staphylinidae (Coleoptera). *Trans. Acad. Sci., St. Louis*, 28: 233-261.
95. WALDEN, B. H. 1911. Orthoptera of Connecticut. *Conn. Geol. and Nat. Hist. Survey Bull.* 16, pp. 48-169, pls. 6-11.
- 95a. WATSON, J. R. 1934. Thysanoptera of the Geenton. *Fla. Ent.*, 18: 44-46.
96. WARMING, EUG. 1909. Oecology of Plants. *Oxford*, 422 pp.
97. WEAVER, JOHN E., AND CLEMENTS, F. E. 1929. Plant Ecology. McGraw-Hill, 520 pp., 262 figs., 1 pl.
98. WEBB, A. O. 1925 (Feb. 7). Animal Ecology of an Illinois Elm-Maple Forest. *Ill. Biol. Mon.*, 9(4): 93 pp., 7 pls.
99. WELD, LEWIS H. 1921. American gall-flies of the Family Cynipidae producing subterranean galls on oak. *Proc. U. S. Nat. Mus.*, 59: 187-246, pls. 28-37.
100. WHEELER, WM. MORTON. 1910. Ants: Their Structure, Development and Behavior.
101. —. 1916. Formicoides. In: BRITTON, W. E. Guide to the insects of Connecticut. Part III. The Hymenoptera. *State Geol. and Nat. Hist. Surv. Bull.* 22, pp. 577-601.
102. WHITEHEAD, W. E. 1919. *Proc. Ent. Soc., Nova Scotia*, 1918, pp. 42-46.
103. WOLLMY, E. 1890. Untersuchungen über die Beeinflussung der Fruchtbarkeit der Ackerkrüme durch die Thätigkeit der Regenwürmer. *Forschungen auf dem Gebiete der Agrikulturphysik*, Bd. 13.
104. —. 1897. Die Zersetzung der organischen Stoffe und die Humusbildungen. *Ibid.*, Bd. 19.





SEX DIFFERENCES IN MORBIDITY AND MORTALITY

By ANTONIO CIOCCO

Department of Biology, School of Hygiene and Public Health, The Johns Hopkins University

INTRODUCTION

THE differences between men and women in relation to the processes that lead to death are of more than passing interest for the student of human constitution. This branch of human biology, it has been emphasized (Pearl and Ciocco, 1936; Ciocco, 1936a, b), has for one of its major objectives to discover and eventually measure the stable organic correlation—integrated biological relations—between the morphological, physiological, psychological, and pathological traits of the individual. Therefore, the differences in morbidity and mortality observed for the two sexes assume special importance not only because the individuals of the two sexes are on the whole also morphologically and functionally differentiated but primarily because the sex dimorphism reflects a dissimilar biological make-up. This, it is of course realized, does not mean that sex differentiation is due simply to the chromosomal constitution of the individuals. In the first place, as Danforth (1932) ably points out, the results of investigations on sex linkage have shown clearly that the so-called sex chromosomes are, one might say, only incidentally concerned with sex differentiation. Besides, as a result of the work of Bridges and of all those who have confirmed and extended his observations (Bridges, 1932), it is accepted that the characteristics of each of the sexes are determined not only by the absence or

presence of one of the sex chromosomes but also by the quantitative balance between the number of sex and autosomal chromosomes. The original simple scheme is further relegated into the background when an explanation is sought for Goldschmidt's observations on the alteration of the sex ratio and on the production of intersexes as the result of crosses between certain varieties of tussock moths. The conclusion which Goldschmidt (1917) reached and which he has maintained since (cf. Goldschmidt, 1938), is that "every individual is able to develop into one sex or the other or any stage between; further that every individual contains all the elements necessary for the development of either sex and its attributes; further that these elements or substances must have a certain quantitative relation to each other in order to secure to one of them the control of development; and that the introduction of quantities in a cross which do not fit the given quantity of the other partner set up the sex differentiation in favor of the higher quantity."

That the final differentiation of sex is dependent also on extra-chromosomal factors is universally admitted today, thanks to the many observations and experimentations reported on gynandromorphism and sex reversal. Thus, the observation by Crew (1923) of the broody hen transformed through disease into a potent rooster is well known. Equally familiar are the studies of Hertwig (1906) continued and elaborated further by

Witschi (1934) to demonstrate how the sex of female tadpoles can be reversed. In recent years, due to the increased knowledge about the function of the endocrines and the chemical composition of the hormones, investigations on the subject have multiplied so that now a more comprehensive idea of the complexity of the processes of sex differentiation has been obtained. The general import of these studies has been dealt with in recent exhaustive reviews by Bridges (1939), Willier (1939), Witschi (1939) and Danforth (1939) and need not be considered here. One may sum up, as Danforth (1932) does, by noting that "We may, then, in the present state of our information, think of somatic sexuality as the expression in each individual of a certain grade of development along special lines. In higher forms the grade attained by each person is primarily conditioned by the particular set of chromosomes which are brought together in the fertilized egg and which determine the direction to be taken in development of fundamental potentialities which are common to all. The direction of this development involves the production of the appropriate type of endocrine system, which in turn is largely effective in supplying the necessary stimuli for the realization of the kind and degree of sexuality foreshadowed in the fertilized ovum." Thus, in comparing the morbidity and mortality of the two sexes or—as is usually the case when dealing with man—of persons who differ relative to the conformation of the external genitalia, the final aim is to arrive at a knowledge of the association between liability and susceptibility to specific diseases and the fundamental biological factors which serve to produce the somatic expression of the two sexes. Although there are still many uncertainties about the actual processes leading to sex dimor-

phism, it is only too evident that humanity could not be segregated so clearly into any two other groups about which the basic factors of differentiation are known in the same degree as is the case for the sexual differentiation into men and women. For this reason particularly, that is, as a new approach to the study of human constitution, this survey of official vital statistics and clinical reports has been undertaken.

THE DIFFERENTIAL MORTALITY IN THE TWO SEXES

Throughout practically the whole life span of man, the rate of mortality of the males exceeds that of the females. In the following tabulation, the life table mortality rates computed by Dublin and Lotka (1936) from data relating to the years 1929 to 1931 illustrate the sex differences in mortality observed in the population of the United States.

It should be noted here that while the figures in Table 1 demonstrate that the mortality of the women is lower than that of the men at all ages, observations in other countries, as well as in the United States in other periods, show that in the early adult life and in the so-called reproductive period women have a slightly higher rate of mortality than the men. Why the life table rates reproduced in Table 1 do not bring out this fact is an item for discussion which will not be gone into at this time (cf. Wiehl, 1938).

The higher mortality of the males has been recognized and quantitatively demonstrated ever since statistical observations on population phenomena have first been made. In his *Natural and Political Observations* (1676) Captain John Graunt reported that more men are born and that more die and that there are more men than women in the population. Yet, he noted, "I have heard physicians say that they

have two Women Patients to one Man, which Assertion seems very likely; . . . Now, from this it should follow, that more Women should die than Men, if the number of Burials answered in proportion to that of Sickness: but this must be salved, either by the alleging, that the Physicians cure those Sicknesses, so a few more die than if none were sick; or else that Men, being more intemperate than Women, die as much by reason of their Vices, as Women do by the Infirmary of their Sex; . . ." Considering the times

TABLE 1

Life table mortality rates of white males and females at decennial ages. United States population of 1930
(Adapted from Dublin and Lotka, 1936.)

AGE (in years)	RATE PER 1,000	
	Males	Females
0	60.86	48.21
10	1.45	1.09
20	3.12	2.70
30	4.12	3.74
40	6.79	5.32
50	12.72	9.55
60	26.35	20.63
70	57.33	48.36
80	128.38	116.06
90	255.13	236.62

this is about as clear a presentation of the problem as could be outlined and it is doubtful whether any progress in this respect has been made since, even though Graunt utilizes the findings mainly as a demonstration of the "*Law of Nature*, that is, the *Law of God*" that man should be monogamous.

Another of the founders of demography, Moheau, (cf. Niceforo, 1925) in 1778 published his famous treatise on the French population and in it the usual sex differences in mortality are demonstrated. To Moheau, these findings seemed contrary to expectations because he believed

that since the female matures earlier than the male her span of life should be shorter. The higher mortality of the men, he opined in view of the data, must therefore result from the more hazardous and laborious life led by them. Somewhat similar was the conclusion of the contemporary English historian Maitland (1739) who, as quoted by Farr (1885), said: "the majority in favour of the males is by our naturalists said to be designed by nature for the support of that part of the human species which is more liable to be destroyed by War than the other. But as war is only casual, and not perpetual, I am of the opinion that this supernumerary supply is designed by nature as a constant remedy against incessant contingencies which the males are more obnoxious to both by land and water than the females."

In sum, if we disregard the teleological aspect of the discussion, these authors as well as the numerous students of the subject who have followed them see in the higher mortality of the males a consequence of the masculine pattern of living. Undoubtedly this social and environmental factor does play an important rôle in the sex differential mortality but it does not explain the whole of the differences between the two sexes, particularly that associated with death in infancy. Quetelet (1835) was apparently aware of this. As usual, he believed that an irregular mode of living and the ease with which the carnal appetites can be satisfied are responsible for the higher adult male mortality. With regard to infants, however, he somewhat lamely, although in italics, concluded: "*Il paraît donc hors de doute qu'il existe une cause particulière de mortalité qui frappe de préférence les enfants mâles avant et immédiatement après leur naissance.*"

As Quetelet and others since have well realized, the higher mortality of the males

in infancy indicates that the aggregate shorter duration of life of men when compared to women can in part only be attributed to the special function of the male in human society. Conceivably other factors must be involved, probably factors which are associated with the inherent biological differences between the sexes. Lending support to such a view are the observations on other animals most of which have been summarized and discussed by Geiser (1923), Parkes (1926), MacArthur and Baillie (1932) and Crew (1937) among others. Of course, precise knowledge about the relative mortality of the males and females of other animals is still not very extensive or conclusive.

With reference to other mammals, the data reported refer mostly to pre-natal mortality and in general are in agreement with the findings about man. The old investigation by Goehlert (1888) which is often quoted found that among horses for every 100 females born dead there are 106 males, while for every 100 females born alive there are only 97 males. The inference drawn from these facts is that the male manifests inferior resistance to the causes of foetal mortality. A similar conclusion is reached from the observations of King (1921) on rats, those of Jewell (1921) on cows, and of Parkes (1925) on pigs. With reference to duration of post-natal life the report of Crew (1925) on pigs is especially interesting. According to Crew, in over 2000 pigs the mortality between birth and weaning was found to be 39 percent of the males and 34 percent of the females.

With regard to birds the weight of evidence would seem to indicate that in general the male is the less resistant of the two sexes. Such is the conclusion reached by Pelseneer (1925) in his review of reports by field naturalists and collectors

of wild birds. Although the reliability of this type of information may be questioned it is in agreement with the observations of Cole and Kirkpatrick (1915) on pigeons and of Haig-Thomas and Huxley (1927) on pheasants.

The most extensive information about birds is obtained, as expected, from data on the domestic fowl. With regard to pre-natal mortality no definitive conclusion can be reached from the recent observations reported. For example, Byerley and Jull (1935) found more females than males among the dead embryos, while Crew (1938) found a slight excess of males. On the other hand, Pearl's (1917) careful study of the sex ratio at hatching based on over 20,000 chicks indicates that slightly more females than males are produced, the proportion being 944 males per 1000 females. Moreover, it is important to note that his data show that for the embryos dying between the tenth day of incubation and hatching the sex ratio is not significantly different from that of the live births. He therefore concludes that for the fowl generally "pre-natal mortality is not differential in respect to sex." With regard to post-natal mortality, however, it would seem that a sex differential exists. According to the studies of Landauer and Landauer (1931) and of MacArthur and Baillie (1932) there is a consistently higher male mortality at least for the first 17 weeks after hatching.

Geiser (1923) who "ransacked the literature" on fishes noted that for the plaice (*Pleuronectes platessa* L. and *Hypoglossoides platessoides* Fahr.), the witch (*Pleuronectes cynoglossus* L.), the salmon (*Salmo salar* L.), the smelt (*Osmerus eperlanus* L.) and the dogfish (*Spinax niger*) the data recorded indicates that the male has a shorter life span than the female. The conclusion reached is based

on the fact that the proportion of males caught is higher in the younger than in the older fish. Of a more precise if not yet satisfactory character are the data reported on the top-minnow, *Gambusia holbrooki* Grd. Geiser (1921) showed for this species that the rate of mortality during a short period of observation was higher for the males than for the females.

Passing to the insects, one finds that in these forms also the males probably have a shorter duration of life. Incidentally while reports on a fairly large number of species have been made with reference to the relative death rate of the two sexes the samples on which they are based are really too small to give reliable results.

There are extensive observations, however, concerning the codling moth (*Carpocapsa pomonella*) and the fruit-fly (*Drosophila melanogaster*). For the former, the tabulations that MacArthur and Baillie (1932) have made of the data published under the auspices of the U. S. Department of Agriculture for many years point to a shorter mean duration of imaginal life in the male. The same is true for *Drosophila* according to the experiments recorded by Pearl (1928). Pearl's analysis which utilizes the actuarial technique indicates that under all conditions of laboratory experimentation the females survive longer than the males.

In sum, from this brief and necessarily fragmentary review of the available and reliable data on the subject, it appears that a lower resistance of the male to the processes leading to death is not peculiar only to man, but is found in other animals as well. To explain this phenomenon so general in nature a number of hypotheses have been introduced such as that it is due to the existence of a sex-linked recessive factor, a sex-limited factor or to differences in metabolism. None

of these theories is satisfactory either because there are too many discrepancies between facts and theory or else the supporting evidence is not probative.

When one examines soberly the phenomenon under consideration and the inquiries which have been made to determine its causes, it will be immediately apparent that one of the most obvious elements of the problem of mortality has been overlooked. This is, that there are many ways of dying as Pearl (1922) emphasizes, quoting well from Seneca:—*nascimus uno modo multis moriur*. More than one of the organs and organ-systems of the body can break down and cause death and until the characteristics of those processes that cause death of the males and of the females are adequately known it seems rather idle to speculate regarding the factors responsible for the apparent inferior survival value of the male. The importance and relevance of this point will become clear, it is hoped, in the survey here presented of the causes of death of men and women of the United States, particularly.

PRENATAL MORTALITY

It has long been established that in man as well as in some other animals (*vide supra*) foetal mortality is higher in the male. The preponderance of male deaths is, for man at least, greatest during the early period of uterogestation and decreases with duration of pregnancy. This phenomenon is well illustrated by the following tabulation made by Ciocco (1938b) of the stillbirths and abortions reported from 1925 to 1934 in a selected birth registration area of the United States. In Table 2 the sex ratio (number of males per 1000 females) has been included in homage to a time-honored custom. Actually the statistical analysis has been based on the masculinity

rate = $\frac{100 \text{ males}}{\text{males} + \text{females}}$ which seems preferable from many standpoints.

During the years from 1925 to 1934, there were more than 180,000 stillbirths and abortions of recognized sex registered in the selected area of the United States. Of these, 57.1 percent were males, giving a sex ratio of 1330.3. The proportion of males decreases rapidly from the second month to the fifth, then the decline is

TABLE 2

Masculinity rate and sex ratio of stillbirths that were registered between 1925 and 1934 in a selected area of the United States. Classified according to period of uterogestation

(From Ciocco, 1938 b.)

PERIOD OF UTEROGESTATION (in months)	MASCULINITY RATE	SEX RATIO	SEX RECOGNIZED IN	
			Number	Percent
Under 2	69.5	2280.0	82	10.1
2	81.2	4311.3	563	27.8
3	78.3	3610.0	2388	63.2
4	66.8	2012.2	6401	89.5
5	58.3	1396.1	12541	97.4
6	55.1	1227.4	17857	99.0
7	52.7	1124.0	23109	99.4
8	55.5	1247.5	28903	99.6
9	57.4	1346.9	68932	99.8
10 and over	57.1	1332.8	2671	99.6
All stillbirths including those of unknown period	57.1	1330.3	181548	96.9

gradual until a minimum is reached at 7 months. Thereafter there is a slight increase. The monthly variation demonstrated in this table is apparently not a random fluctuation of the sex ratio for the total because the Lexis coefficient indicates that the standard deviation of the monthly fluctuations of the masculinity rates is more than ten times the standard deviation of the masculinity rate of the total.

The trend of the sex ratio by month of

uterogestation as observed here is in good agreement with that reported by Auerbach (1912) on stillbirths and abortions in Budapest, and by Tschuprow (1915) on those of Budapest, Vienna and Paris. Schultz (1921), who has discussed this question in detail, believes that the high masculinity noted in the early months of uterogestation as deduced from official vital statistics is probably exaggerated due to error in recognizing the sex of the foetus in the early stages of intrauterine life. In his collection of over 1400 fetuses deriving in the majority from spontaneous abortions he found the sex ratio equal to 1210 in the third month, 1175 in the fourth, 1096 in the fifth, 875 in the sixth, 1085 in the seventh, 1333 in the eighth and 1676 in the ninth and tenth months. For the months preceding the seventh, these figures are markedly below those shown in Table 2. A glance at that table, which also gives for each month the percentage of stillbirths in which sex was recognized, clearly indicates the difficulty encountered in sexing the individual and emphasizes, in agreement with Schultz, that the sex ratio in the early months of uterogestation is open to doubt. However, it is the opinion of most students, including Schultz, that among the antenatal deaths masculinity is at a minimum from the 5th to the 7th month and higher in the preceding and subsequent periods. A dissenter from the consensus of opinion is Boldrini (1930), who notes that among the very young embryos collected in the Carnegie Institution and described by Streeter (1920) and by Spaulding (1921), there are more females than males. Assuming that the collection of these two observers is a random sample of abortions he concludes that actually more females than males die in the very early periods of pregnancy, and that the difference is such that it more than balances the subsequent relative

higher masculine mortality. Or, in other words, Boldrini accepts the concept of modern genetics that the probability of conception is equal for males and females, and believes that the preponderance of males at birth is a consequence of the relatively high female mortality which takes place in the first two months of pregnancy and which is never balanced by the later excess of deaths among the males. Boldrini's tentative conclusion is considerably weakened by the fact that a study by Wilson (1926), also on material collected in the Carnegie Institution, reveals that histological examination of the embryo is often in disagreement with the diagnosis of sex made by external examination. A considerable margin of error in the sexing is noted especially for embryos already labelled females and which his observations revealed to be males. In view of this, the basic evidence from which Boldrini draws his conclusions is not absolutely reliable. However, as has been pointed out (Ciocco, 1938a) some such conclusion is necessary in order to explain the sex ratio if it is true that the same number of males and females are conceived. No other facts have ever been presented to substantiate a theory based on a preponderant female mortality in the early period of uterogestation and even if it is assumed that the official vital statistics of intrauterine deaths up to the fourth month of uterogestation are grossly erroneous and unreliable relative to sex, there seems to be no doubt that from the fifth to the seventh month there is a decline in the masculinity rate and that the monthly fluctuations of the masculinity rates from the fifth to the tenth month are greater than would be expected if chance alone were operating. All of this expresses the fact that the pattern of the duration of intrauterine existence is different among stillbirths of the two sexes.

Of the factors that contribute to a different behavior of the two sexes with respect both to the frequency of intrauterine mortality and its pattern relative to duration of uterogestation, those included in the list of the causes of stillbirth are the ones which to a certain degree should throw some light on the significance of these observations. Any such expectation, however, has limitations, since the official list of the causes of stillbirths actually is concerned more with the environmental factor, in this case the mother, than with the pathologic state of the foetus. Moreover, for over 25 percent of the stillbirths in this sample the causes were not specified or were unknown. Omitting them and limiting the observations here only to the major categories of stated causes, and truly to those for which the sample is sufficiently large, the results shown in Table 3 are obtained.

Table 3 presents the masculinity rates of the stillbirths according to the more important major categories of causes of foetal deaths as observed, and when correction is made for the time of uterogestation when the foetus was expelled. This correction is necessary because it has been shown (Ciocco, 1938b) that the differences in the distribution of the male and female stillbirths in general exist independently of the causes of death. The correction has been applied by making the distribution of the time of foetal expulsion for the deaths from each cause equal to that found for all deaths.

From the uncorrected data of Table 3, it appears that masculinity is lowest for Malformations; in particular for Spina bifida for which the sex ratio is 560 and "Other" malformations with a sex ratio of 624, while for Hydrocephalus, the sex ratio equals 1108. Among the important causes the highest sex ratio occurs in stillbirths due to Difficult labor—it reaches a

maximum of 22.59 for stillbirths accompanying Version. When the usual statistical procedure is applied to determine whether the fluctuations of masculinity rates for each cause category can be regarded as chance deviations from the masculinity rate for all causes, it is found that the masculinity rates for Malforma-

TABLE 3

Crude and corrected masculinity rates for the more important categories of causes of foetal mortality
(Adapted from Ciocco, 1938 b.)

CATEGORY OF CAUSES	MASCULINITY RATE		NUMBER OF STILLBIRTHS
	Crude	Corrected for differences in utero-gestation duration	
Malformations.....	42.8	42.7	9,262
Albuminuria and other diseases incident to pregnancy.....	53.9	54.8	11,031
Death in utero.....	56.7	56.8	6,969
General diseases.....	57.0	56.9	6,255
Diseases of the placenta and membranes.....	57.1	57.2	18,144
Asphyxia of child (cause not stated).....	58.1	58.1	6,495
Prolapse and compression of cord.....	58.1	58.1	16,756
Malpresentation.....	58.8	59.1	8,357
Abortion, miscarriage, premature birth.....	59.3	55.8	12,040
Traumatism and overwork.....	59.6	58.3	5,116
Difficult labor.....	62.7	61.0	15,755
All specified causes.....	56.9	56.9	127,334

tions and Albuminuria *et al.* are significantly lower than that for the total of all causes. The first category includes Hydrocephalus, Spina bifida and "Other" malformations. For all these subdivisions the masculinity rate is significantly lower than that of all causes. The same is true for stillbirths due to Albuminuria, Toxaemia and Eclampsia, subdivisions of the Albuminuria *et al.* category, but it is

not true for stillbirths due to Nephritis which are also included under this general heading. The major categories of causes of stillbirths which have a masculinity rate significantly above that of the total are Abortions *et al.* (but not the subdivision "Other premature"), Prolapse and compression of cord (true only for Prolapse), Malpresentation, Traumatism and overwork (excluding blow, fall, shock and overwork) and Difficult labor. The last class includes stillbirths associated with Deformed pelvis, Instrumental delivery, Version and "Other"; for all of these the masculinity is significantly high compared to that of the total.

When the correction is applied the rank of the masculinity of the several causes remains about the same with but the one notable exception due to the considerable drop of the masculinity rate of Abortions *et al.* This has occurred because the weighting used in the correction has reduced considerably the effect of the high masculinity of those who died at 4 months and under and who constitute a considerable bulk of the stillborn listed in this group. It appears then that, duration of uterogestation being made uniform, the masculinity of stillbirths and abortions varies with respect to the major groups of causes of stillbirth in the following manner:

1. Masculinity is the lowest for stillbirths said to be due to Malformations. In fact more females than males are among the stillbirths included in this group of causes and consequently the masculinity for this group of 42.7 is far below that of the live births, which was 51.4 for the United States in the same period.

2. Stillbirths included in the Albuminuria group have a masculinity rate of 54.8 which is slightly higher than that for live births but lower than the stillbirth mascu-

linity rate from all causes in this selected area.

3. The masculinity rates of stillbirths apparently due to general diseases such as Syphilis, Diseases of placenta and membranes, Asphyxia of child (cause not stated) and to Traumatism and overwork or those included under the category of Death in utero and Abortions ("Other premature") do not differ significantly from the masculinity rate of the stillbirths from all causes. The same is probably true of stillbirths due to Prolapse and compression of cord. The masculinity for this group of causes, it will be noted, is remarkably close to that for Asphyxia (cause not stated). These two categories presumably produce foetal death in a similar manner.

4. The two groups of causes of stillbirths associated with parturition—Malpresentation and Difficult labor—have definitely the highest masculinity rates. In the latter group are included practically twice as many males as females, the masculinity rate being equal to 61.0.

The outstanding characteristics of the pattern of male and female foetal mortality derived from the above statistics are found also in the data that Bundesen and his associates have collected on stillbirth mortality. In an elaborate investigation which is rather unique for its thoroughness, Bundesen *et al.* (1937) have performed post-mortem examinations routinely on as many stillbirths as possible in the Chicago area. Their findings in relation to the sex of the deaths have not been published as yet but through the courtesy of Dr. Bundesen, to whom this writer wishes here to express his thanks, the needed information has been made available for this paper. During the years 1936 and 1937 Bundesen *et al.* performed satisfactory postmortem examinations on close to 1000 stillbirths. In Table 4 are given the masculinity rates in relation to the major classes of patho-

logic diagnoses as grouped by these investigators.

It is to be noted first of all that of the total 985 stillbirths examined 524 are males giving a masculinity rate of 53.20. This is lower than that found for the total registration area, but much higher than the masculinity rate for live births. From the standpoint of this study, the most important finding is that the lowest masculinity rate is associated with deaths due to malformations and tumors, while the highest occurs in the hemorrhage and injuries group. Of great interest is the category that includes stillbirths where no

TABLE 4

Causes of death in male and female stillbirths. Results of satisfactory autopsies made on an unselected sample of foetal deaths occurring in Chicago in 1936 and 1937

(Data supplied by H. N. Bundesen.)

CAUSE OF DEATH	NUMBER OF STILLBIRTHS	MASCU- LINITY RATE
Malformations and tumors.....	97	41.2
Infections.....	32	46.9
No pathologic lesion.....	480	53.8
Asphyxia.....	213	55.9
Hemorrhage and injuries.....	163	56.4
All deaths.....	985	53.2

organic lesion could be found at autopsy. In this category, it will be noted, fall almost one-half of all the stillbirths. The question arises: do these represent "bad eggs," that is *constitutionally defective* individuals? Does the fact that for this group the masculinity rate equals the rate of all the stillbirths have any significant bearing upon the riddle of the sex ratio at conception? To pursue this aspect of the problem in more detail would take us too far afield, but it is to be emphasized that when an experienced observer is unable to find any visible organic reason for the death of about one-half of the stillbirths one is justified in assuming that for these

deaths the constitutional factor is highly important.

The main conclusion to be drawn from these data is that when stillbirths are grouped according to the presumed cause of death there is a significant variation in the sex ratio of deaths from each cause. Females predominate when the foetal mortality is essentially the result of defective embryonic development, a part of which cases certainly rests biologically upon defects in genetic constitution. On the other hand, masculinity is high when either the placental structure is faulty or is inadequate to safeguard the foetus from toxic elements transmitted by the mother. Finally, masculinity is highest when still births result from a combination of environmental factors, among which the relative size of the foetus in proportion to that of the birth canal is very important. These facts do not appear to support the general assumption that the male is inherently weaker and certainly cannot be used to bolster Lenz's (1931) views that there is in the high masculinity of stillbirths evidence of the action of a lethal gene. Riddle's (1927) theory that the phenomenon is a consequence of maladaptation of the male embryo to the female environment is not contradicted by these findings. However, on the basis of the observations alone it would seem safer to say with Pfaundler (1936) that this phenomenon is the effect of both genetic and environmental factors, particularly when it is considered that the preponderance of males among stillbirths resulting from defective placental structure or from trauma at labor may well be regarded as the consequence of the difference in the rate of physical development between the two sexes.

POST-NATAL MORTALITY

The clinically recognizable conditions that can bring about the death of an indi-

vidual are many. Over two hundred are listed in the International Classification alone, and it is on the basis of this list that official vital statistics are prepared. For the purpose of this study, a regrouping of the causes of death presented in the official reports will be made so as to bring together all the fatal entities which cause death because of the functional breakdown of a particular organ-system. Such a grouping is embodied in the procedure developed by Pearl (1920) who set up the following classification:

- I. Circulatory system, blood, and blood-forming organs.
- II. Respiratory system.
- III. Primary and secondary sex organs.
- IV. Kidneys and related excretory organs.
- V. Skeletal and muscular systems.
- VI. Alimentary tract and associated organs concerned in metabolism.
- VII. Nervous system and sense organs.
- VIII. Skin.
- IX. Endocrinal system.
- X. All other causes of death.

With some modification this classification will be employed here to illustrate, on the basis of the 1930 mortality of the white population of the United States, the degree and direction of the differences between the sexes. The modifications concern the items Premature birth and Injury at birth, both of which Pearl includes in class III and are here considered apart; and the item Violent and accidental deaths which is here discussed separately from category X of Pearl's classification.

With the exception of class III for each of the biological groups of death causes listed above the sex differences in the rate of mortality have been computed and are shown in Table 5. The rates are based on the number of deaths per 100,000 males or females exposed to the risk of dying in

1930. For reasons which need not be gone into here the number of exposed to risk used in these computations is composed of (a) the white population of age 1 year and above as enumerated by the census of 1930, and (b) the number of white births of that year in the registration states.

The deaths due to a break-down of the primary and secondary sex organs have been omitted because with two exceptions they include causes that concern respectively either the males or the females only. Obviously for these organs peculiar to the

cess male mortality. From Table 5, when all the listed causes of death are considered, it is seen that 7 of the 8 groups exhibit a higher male mortality and only one—endocrinal system—has a superior female mortality. It is seen, moreover, that the deaths due to a break-down of the circulatory system contribute most to the excess male mortality, followed in order by the deaths referring to the respiratory system and to the nervous system and sense organs. Least of all is the higher male rate augmented by deaths from the

TABLE 5

Sex differences in the rates of mortality (per 100,000) from the several biological groups of causes of death (excluding primary and secondary sex organs). White populations of the United States Registration Area, 1930

ORGAN-SYSTEM	INCLUDING ALL LISTED CAUSES OF DEATH		INCLUDING ONLY MAJOR* LISTED CAUSES OF DEATH	
	Number of death causes	Differences in rates**	Number of death causes	Differences in rates**
Circulatory, blood	35	+50.2	15	+47.8
Respiratory	23	+34.2	11	+31.0
Nervous, sense organs	28	+33.5	14	+33.0
Alimentary tract	37	+25.6	17	+24.7
Kidney and excretory	11	+8.9	6	+6.9
Skin	11	+1.9	2	+1.4
Skeletal, muscular	12	+0.5	2	-0.8
Endocrinal	7	-13.0	2	-11.4

* Cause of death of at least 1000 males or females, respectively, during 1930.

** + indicates rate higher in males, - indicates rate higher in females.

male sex, the prostate for example, the mortality is restricted to the males; while for diseases involving the ovaries and uterus the mortality is all attributed to the female sex which also dies from unique conditions such as other puerperal hemorrhage, abortions, puerperal septicemia and pyemia. Altogether for this group of causes the females have the higher mortality rate, exceeding that of the males by 44.6 per 100,000.

The findings presented in Table 5 indicate for what group there is an excess of male deaths and therefore how much each organ system contributes to the total ex-

cess male mortality. The order of these differences, it should be noted, is practically the same as that of the frequency of the several groups of causes of death. A break-down of the circulatory system is responsible for the highest number of deaths and it contributes most to the excess male mortality, while deaths from a break-down of the skin, skeletal and muscular systems are relatively few and for these the differences between the mortality of the males and females are small. The outstanding fact to emerge from this tabulation is the reversal of the usual higher male mortality

in the case of deaths due to a break-down of the endocrinal system. Therefore, as has been seen relative to pre-natal deaths, there are conditions for which the females and not the males manifest the higher mortality. In view of this, the question may be raised whether within each group there are only certain specific causes of death for which the males exhibit a higher mortality or whether this is true for all causes. In order to arrive at a definite answer to this question it is necessary to limit the inquiry to those causes of death involving an adequate number of persons. When the investigation on this point is limited to those causes of death stated to be responsible at least for either a thousand male or else one thousand female deaths during 1930, the net changes in the pattern of the sex differences are seen in the last two columns of Table 5. The total number of causes of death to be examined is reduced by almost one-third from 164 to 69 but for each group of causes the amount of the difference between the male and female mortality rates remains about the same. The omission of twenty death causes listed in the circulatory, etc. class reduces the higher male mortality by only 2.4 per 100,000. Similarly, although by this means of selection the number of causes of death included in class VIII (Nervous system, etc.) is lowered by one-half to 14, yet the total male excess is only reduced from 33.5 per 100,000 to 33.0. The only remarkable change produced by the selection of the major causes of death regards the deaths due to a break-down of the skeletal and muscular systems. For these, only 2 out of the 12 causes included have brought about the death of either a thousand males or females and the latter predominate in both instances.

The differences between the male and female mortality rates for the specific major (as defined) causes of death included

in each of the eight groups have been tabulated and are shown in Table 6. It is seen from this table that the males have a higher death rate from 52 of the 69 causes listed, 76 percent, while the females have the greater mortality from 17 of the causes. Incidentally, if all the causes of death had been included it would have been found that the males have a higher death rate from 74 percent of the causes. From Table 6 it is also to be observed that for 31, or almost one-third of the listed death causes, the difference between the male and the female rate is equal to less than one per 100,000. These findings would indicate then that the higher mortality of the males is not general but limited to certain causes of death only.

If a difference in rates equal to or greater than 1 per 100,000 is taken as representing an important deviation of the mortality in favor of one or the other sex, it is seen that for 32 major causes of death the males show such an excess, while for 6 the females exhibit the same degree of higher mortality. Considering the causes of death for which there is an excess of male deaths, Table 6 shows that 9 are included in the group of circulatory diseases. In order of male excess, these 9 causes of death are: angina pectoris, chronic myocarditis, other unspecified diseases of the heart, diseases of the coronary arteries, arteriosclerosis, other myocarditis, endocarditis specified chronic and other valvular diseases, congenital malformations of the heart and aneurysms. This list is very interesting both for its omissions and inclusions. It includes all except one of the death causes in which the main pathology lies in the arteries, it includes two of the four listed causes in which the diagnosis specifically implies a break-down of the myocardial layer, but it includes only one of the four items that are based on a diagnosis of a primary defect of the endo-

cardium. The importance of the breakdown of the arteries and myocardium so far as the greater male mortality is concerned is better realized when one considers that the excess of the male rates for

cific major causes listed in the respiratory group and for which the male mortality is higher than the female by 1 per 100,000 are, in order: lobar pneumonia, tuberculosis of the respiratory tract, broncho-

TABLE 6

The major (cf. Table 5) causes of death included in each category of the biological classification distributed according to the difference between the male and female mortality rates (per 100,000)

DIFFERENCE IN MORTALITY RATES (PER 100,000) + = higher rates in males - = higher rates in females	ORGAN-SYSTEM							
	Circ.	Resp.	Nerv.	All.	Kid.	Skin	Skel.	Endoc.
- 8.0-8.9	—	—	—	—	—	—	—	1
7.0-7.9	—	—	—	—	—	—	—	—
6.0-6.9	—	—	—	—	—	—	—	—
5.0-5.9	—	—	—	—	—	—	—	—
4.0-4.9	—	—	—	—	1	—	—	1
3.0-3.9	—	—	—	1	—	—	—	—
2.0-2.9	—	—	—	1	—	—	—	—
1.0-1.9	—	—	—	1	—	—	—	—
<-0.9	3	2	1	2	1	—	2	—
<+0.9	3	3	8	4	1	1	—	—
+ 1.0-1.9	1	2	2	1	1	1	—	—
2.0-2.9	3	1	—	1	1	—	—	—
3.0-3.9	1	1	1	2	—	—	—	—
4.0-4.9	—	—	—	3	—	—	—	—
5.0-5.9	—	—	1	1	—	—	—	—
6.0-6.9	1	—	—	—	—	—	—	—
7.0-7.9	1	—	—	—	1	—	—	—
8.0-8.9	1	—	—	—	—	—	—	—
9.0-9.9	—	—	—	—	—	—	—	—
10.0-10.9	—	1	—	—	—	—	—	—
11.0-11.9	—	—	—	—	—	—	—	—
12.0-12.9	1	—	—	—	—	—	—	—
13.0-13.9	—	1	—	—	—	—	—	—
14.0-14.9	—	—	—	—	—	—	—	—
15.0-15.9	—	—	—	—	—	—	—	—
16.0-16.9	—	—	—	—	—	—	—	—
17.0-17.9	—	—	1	—	—	—	—	—
Total.....	15	11	14	17	6	2	2	2
								69

diseases of the arteries and myocardium constitutes 72 percent of the total excess of the male mortality from diseases of the circulatory system and if the cause "Other unspecified diseases of the heart" is added, as it probably should be, then the percentage rises to 87 percent. The six spe-

pneumonia, cancer of the respiratory tract, other respiratory diseases, influenza, and respiratory diseases complications specified. Interest in this list centers about two facts: First, all the forms of pneumonia except one are listed here. In the second place cancer and tuberculosis of the

respiratory tract are both listed here although they are different in their incidence, particularly with respect to age range. In sum, in this list we find only, or practically only, and almost all the causes that involve a break-down of the lung tissue proper.

The five listed causes of death for which the males have higher death-rates than the females in the nervous system group are, in order: suicide, alcoholism, general paresis, epidemic cerebrospinal meningitis and tabes. These five causes of death are notable because they give some indication of one of the important causes of the differences in the male and female mortality. This is, that the males and females lead a different kind of life. Thus alcoholism and suicide might in a very broad fashion be regarded as different aspects of the same phenomenon related with the personality reaction to the social environment. The stress and strain of social actions is definitely greater for the males than for the females and the differences in mortality relative to alcoholism and suicide might be explained on that basis. Similarly, one notes that tabes and general paresis and epidemic cerebrospinal meningitis are all diseases of an infectious nature and for which the exposure is certainly higher in the males. How much this is responsible for the higher male mortality remains, however, to be seen.

The solitary cause of death with a markedly higher male mortality included in the skin group, is cancer of the skin. Except that it is higher in certain occupational categories of persons the etiology of this type as of other types of cancer is unknown. Obviously, the question here is whether the whole difference in the rates of males and females is not due to the fact that occupations which involve exposure to sun, tars, etc. are statistically speaking male occupations.

Among the causes of death included in Class IV (kidney, etc.), there are three for which the male rate is greater than the female rate by 1 per 100,000 or more. These are: chronic nephritis, cancer of the bladder and nephritis, nephritis unspecified (10 years and over). The excess of males among deaths due to nephritic disease is to be expected due to the higher incidence of the so-called degenerative forms of heart disease. In the group of kidney diseases, is included one of the 19 causes of death for which the death rates of the females are higher than those of the males. This is puerperal albuminuria and eclampsia which may be regarded as the indication of an inferior organization of the kidneys that becomes manifest through the process of pregnancy.

There are eight specific causes of death in the class of diseases of the alimentary tract for which the males demonstrate a higher mortality rate than the females by at least 1 per 100,000. These eight causes of death are a heterogeneous lot consisting of, in order: appendicitis, cancer of the buccal cavity, diarrhea and enteritis (under 2 years of age), ulcer of the stomach, cirrhosis of the liver, cancer of the digestive tract, ulcer of the duodenum and typhoid fever. In this list one notes two diseases in which the chances of infection are important—diarrhea and enteritis (under 2 years of age) and typhoid fever. There are three causes of death representing unknown etiology, namely cancer of the buccal cavity, of the digestive tract, and cirrhosis of the liver; two diseases in which the unknown etiology is associated with psychosomatic changes, namely ulcers of the stomach and duodenum; and finally, appendicitis about which neglect of symptoms is probably the main factor responsible for fatal consequences.

As is shown in Table 6, there are three causes of death in this group for which the

females show a higher mortality than the males. These are: pellagra, other diseases of the gall-bladder and biliary calculi. The first is a nutritional deficiency disease, the second and third are probably associated with the peculiar anatomic structure of the female. The females prevail also in the case of deaths due to endocrine diseases. In this category the two causes of death for which the difference between the mortality rates of the males and females is greater than 1 per 100,000 are diabetes and "other diseases of the thyroid." The females, as seen, have a higher mortality rate from both of these causes.

Summing up this examination of the sex differences in mortality rate according to the biological classification of causes of death and in relation to the specific causes as listed in the official statistics the findings that stand out are:

1. The mortality of the males is higher than the females for the causes of death involving primarily the myocardial layer of the heart, the arteries, and the lungs.

2. To the higher mortality of the males contribute the deaths due to conditions

in which is important the reaction to social environment (alcoholism, suicide, stomach and duodenal ulcers); occupation (skin cancer); and exposure to risk of infection (neurosyphilis, epidemic cerebrospinal meningitis, pneumonia, and influenza).

3. On the other hand, the females show a higher mortality than the males as expected from diseases associated with pregnancy and primarily from diseases involving the endocrine system.

Thus the differences between the males and females relative to mortality may be summarized to say that the former exhibit a higher mortality from diseases among which the so-called chronic degenerative pathological processes predominate and from diseases which might be attributed to the social function of the sex, while the females compared to the males show a higher mortality in relation to conditions related to the function of reproduction and in addition manifest striking susceptibility to causes directly or indirectly deriving from a break-down of the endocrine system.

(To be concluded)



species of sharks and rays. The conclusions confirm the criticism of Hertwig's theory made by Jacobshagen in 1923 (*Placoidorgane und Selachierzähne, Heidelberg*). The bibliography includes 29 titles.



GENETICS

AN INTRODUCTION TO GENETICS.

By A. H. Sturtevant and G. W. Beadle.
W. B. Saunders Co., Philadelphia and
London. \$3.25. $7\frac{1}{2} \times 5\frac{1}{8}$; 391 + 1 fold-
ing chart; 1939.

In this scholarly work, the authors have hit a new trend in pedagogy. They have developed a course in the ever-growing field of genetics which follows a logical rather than a historical approach to the subject. Stress is constantly placed upon the fact that genetics is a quantitative science, depending largely upon mathematical analysis and interpretation for its fundamental basis.

The text is written as an introduction to the field, and hence is to be used by students who are coming into contact with genetics for the first time in their lives. From this point of view, it is the reviewer's opinion that there is much that is too theoretical and technical for the beginning student to grasp, even though he may have a fair background in general biology. The problems at the end of each chapter will undoubtedly be an aid in teaching the course, but one wonders whether it would not be better, from the student's point of view, if some of the problems dealt with some actual simple mating problems in *Drosophila*, rather than having all of them confined to technical and mathematical phenomena encountered in theoretical genetics.

The subject matter is intended to deal with the general subject of genetics, but one finds that the space allotted to plants and to animals other than *Drosophila* is quite small. Hence the volume may be described as an excellent treatise on the theory and mathematics of the technical genetics of *Drosophila*.

THE GENETICS OF COTTON.

By Sydney C. Harland. *Jonathan Cape, London*. 10s. 6d. net. $8\frac{1}{2} \times 5\frac{1}{8}$; 193; 1939.

This book is written primarily for geneticists. It will also be of interest to growers developing new types of cotton, since it covers rather completely the work done in cotton genetics up to 1937. A fair knowledge of botany and a good knowledge of genetics is required of the reader. The inclusion of illustrations of the phenotypic characters analyzed would be of aid to the student of heredity possessing a limited botanical background.

The subject matter is divided into three main sections and several minor ones. The former are: taxonomy, cytology, and genetics. The latter are: linkage, mutations, hybridization, polyploidy and haploidy, comparative genetics, and evolutionary history. The portion of the book dealing with genetics is especially fine and the outline method used makes for ready reference to any factor treated. The gene symbolism employed is at times obscure but a reading of the paper, *Gene Symbols for Use in Cotton Genetics*, (Hutchinson and Silow, *Jour. of Heredity*, 30 : 461; 1939) by members of Harland's own laboratory will aid the reader. The bibliography contains 209 titles. The table of contents and the index are well prepared.



EXPERIMENTS IN BREEDING HOLSTEIN-FRIESIAN CATTLE FOR MILK- AND BUTTERFAT-PRODUCING ABILITY, AND AN ANALYSIS OF THE FOUNDATION COWS AND OF THE FIRST OUTBRED GENERATION. U. S. Department of Agriculture. *Technical Bulletin* No. 677.

By M. H. Fohrman and R. R. Graves.
Government Printing Office, Washington.
15 cents. $9\frac{1}{2} \times 5\frac{1}{8}$; 81; 1939 (paper).

It was found in 1918 that among dairy-cattle breeders about two-thirds of the cattle were failing to return a profit to their keepers. As a result the Bureau of Animal Industry set up a carefully controlled experiment to afford dairy farmers a better understanding of the laws of inheritance as they apply to milk and butterfat production.

Forty-one foundation cows were bred to a single sire. Detailed reproduction records are given, and also milk and butterfat production of dams and daughters. Analysis shows that the sire had an inheritance for a level of production below that of the three highest-producing dams, but better than that of the lower-producing dams. There is a high correlation between production of dams and daughters, although the daughters show less variability. Final determination of the influence which this sire had on the germ plasm of the offspring will depend upon analysis of production records of the second generation.



AN INTRODUCTION TO MODERN GENETICS.
By C. H. Waddington. *The Macmillan Co., New York.* \$4.00. 8½ x 5½; 441; 1939.

This excellent text on genetics is unusual in that it proceeds beyond the fundamental Mendelian concepts and the experimental techniques centering about the behavior and mechanics of chromosomes at which point the average text stops. The author then applies genetics to wider problems—development, evolution, animal and plant breeding, and human affairs. Finally, there is a discussion of the nature of the gene. A section on laboratory methods for class work on *Drosophila* is appended to the text. There are two indices—the first by bibliography and author, and the second by subject. The book is amply illustrated with charts, diagrams, photographs and drawings.



GENERAL BIOLOGY

THE ORGANISM. *A Holistic Approach to Biology Derived from Pathological Data in Man.*

By Kurt Goldstein. *American Book Co., New York.* \$4.00. 7½ x 5½; xvii + 533; 1939.

This is a translation from the German original, published in 1934, but with some changes in the arrangement and a number of additions and omissions. Principally a critical discussion of method, the author

nevertheless brings in a wealth of illustrative material (to a large extent his own work on patients afflicted with mental derangements or brain abnormalities, although the work of others is by no means neglected) "essentially supposed to demonstrate over and over again that *method as well as theory must originate from nothing but the most concrete evidence.*" His point of departure is man "primarily because he has found no concept more problematic than the *concept of simplicity.*"

Even in the analysis of human behavior, the attempt to reduce the more 'complex' performances to the 'simpler' ones has met with the greatest difficulties. Very often, the 'simpler' performances have been found to be abstractions, and the events which the latter aim to explain turn out to be 'simple' only in the presence of a specific, habitual, technical attitude of abstraction. At closer range, however, the 'simple' phenomena have been found to be much more obscure. . . . Such difficulties make one suspicious of attempts to differentiate between 'higher' and 'lower' animals, or to understand the 'higher' in terms of the 'lower.'

In the several chapters the author discusses such matters, among others, as normal ('ordered') behavior and 'disordered' behavior, the nervous system, modification of function due to impairment of the organism, the nature of partitive processes (reflexes, instincts, 'drives'), conception of the organism as a whole, the nature of biological knowledge, and norm, health and disease (including anomaly, heredity, and breeding).

The book is worth study by the biologist, physician, psychologist—in fact all those interested in the study of the nature and behavior of the living organism. Bibliographies are provided for the separate chapters, and there is an index.



BIO-ECOLOGY.

By Frederic E. Clements and Victor E. Shelford. *John Wiley and Sons, New York.* \$4.50. 9 x 5½; vi + 425; 1939.

Many criticisms have been leveled at ecologists and the science of ecology for falling into the pitfalls of all new disciplines. This, of course, is to be expected, but the most serious fault is that to a considerable extent it still continues in this direction with but little attempt

to rectify the errors which have variously been accredited to "careless observation and experimentation", "lack of intellectual focus", etc. Animal and plant ecology have become so separated that one might think that plants and animals have no influence one upon the other. The definition and numbers of ecological "concepts" have reached meaningless proportions. Fortunately the present book attempts a synthesis of the present state of ecological knowledge by considering both plant and animal ecology together as one subject, which is without a doubt a sensible approach. Ecological nomenclature has been subdued. The two authors are of the highest eminence in their respective fields, and the fact that this book is a product of their collaboration should make it a valuable and informative text, which it is.



A DICTIONARY OF SCIENTIFIC TERMS: Pronunciation, Derivation, and Definition of Terms in Biology, Botany, Zoology, Anatomy, Cytology, Embryology, Physiology. Third Edition.

By I. F. Henderson and W. D. Henderson.

Revised by J. H. Kenneth. D. Van Nostrand Co., New York. \$7.00. 8½ x 5½; xii + 383; 1939.

The original edition of this dictionary contained definitions of about 10,000 terms used in biology and its allies, anatomy, botany, zoology, embryology, cytology and physiology. Some terms in bacteriology and palaeontology were included. In the second edition about 1500 new terms were added while in the third comparatively few were. It was not the authors' plan to list all terms in biological literature—since this would run the work up into a good-size dictionary—but rather to produce a small, handy volume. Students, readers and those having to do with the publication of biological literature will find this a useful book.



WILDLIFE OF THE ATLANTIC COAST SALT MARSHES. U. S. Department of Agriculture. Circular No. 520.

By W. L. McAtee. Government Printing Office, Washington. 10 cents. 9½ x 5½; 28 + 6 plates; 1939 (paper).

Salt marshes of the Atlantic coast are undergoing intensive draining and ditching in furtherance of mosquito control, and as a consequence much of the salt-marsh fauna and flora is being depleted. McAtee asks that some consideration be given to the conservation of this wildlife. He describes the typical plants, birds, reptiles, and mammals that inhabit such areas to acquaint the layman with the resources of these interesting biological habitats.



THE BULLETIN OF MATHEMATICAL BIOPHYSICS. Volume 2, Number 1, March, 1940.

Edited by N. Rashevsky. University of Chicago, Chicago.

This number contains the following papers: A neural mechanism for discrimination: II. Discrimination of weights, by A. S. Householder; An approach to the mathematical biophysics of self regulation and cell polarity, by N. Rashevsky; Contributions to the mathematical biophysics of organic form: I. Formation of cavities in cellular aggregates, by N. Rashevsky; Discrimination between temporally separated stimuli, by H. D. Landahl; Convective diffusion in parallel flow fields, by Gale Young.



HUMAN BIOLOGY

AMERICANS. A New History of the Peoples Who Settled the Americas.

By Emil L. Jordan. Illustrated by Edward A. Wilson. W. W. Norton and Co., New York. \$3.50. 8½ x 5½; 459 + 8 plates; 1939.

To say that a book is "ingenious" sounds somewhat awkward, yet this adjective can be very appropriately applied to the work under discussion. The stories of the many peoples who have contributed to the making of modern America have been told and retold, but this is the first time that all of them have been integrated into a simple narrative covering both Americas.

It is now almost universally held that the human species originated in the general vicinity of southeastern Asia, from which point of origin mankind has radiated over the inhabitable world. The first settlers in America came from Asia across Bering Strait, because that was the shortest route. They brought no civilization with them for they had as yet not developed any: the pre-Columbian civilizations of Latin America were indigenously developed. After an interval of five thousand or more years the pathway from Europe to America was discovered, and a new stream of immigrants began to cross the Atlantic, bringing a ready made civilization with them. The American continent became the battle ground of two civilizations, and although the exotic one was victorious many of the indigenous characteristics of America became indelibly grafted upon it.

It is the story of the fusion of these two unrelated cultures to form Saxon and Latin America that the author brings to us in a fresh and stimulating form. In Saxon America the Europeans settled on the Atlantic seaboard, gradually advancing toward the west and pushing the aborigines before them. In Latin America they attempted the simultaneous colonization of the entire continent, making it necessary to assimilate the aborigines instead of expelling them. Thus Latin America had no frontier, and consequently no counterpart of the picturesque personalities that developed along the frontier of Saxon America. A few comparisons may be made; for example, Bartolomeo Las Casas with David Zeisberger, but Latin America had no Heinrich Stiegel, no Cleng Peersen, no Emperor Norton, no Johnny Appleseed.

There is an ample index of fifteen pages, but the book suffers by lack of adequate documentation. The author's fondness for presenting romantic characters in a dramatic light (an admirable trait in an author) leads him to make statements that the careful reader will wish to check before accepting as authentic, but the absence of footnotes precludes this.

The treatment of certain personages leaves much to be desired. Of Anne Hutchinson it is recounted merely that she was expelled from Massachusetts for

heresy and was subsequently murdered by an Indian. There is not a word about the significant influence on subsequent history exercised by her and her followers after they had established the colony of Rhode Island. She might better have been left unmentioned entirely.

There is much more that might be said about this comprehensive work, which, despite this criticism is delightful reading. In its pages one meets the makers of history who have long suffered undeserved neglect in this country—Bolívar, O'Higgins, and the only really humanitarian dictator in American history, Don Pedro II. The chapters dealing with the cultural contribution of the Spaniard and the ethics of the Eskimo are quite enlightening, and he who undertakes to read the book is not likely to put it down unfinished.



WE DIDN'T ASK UTOPIA. *A Quaker Family in Soviet Russia.*

By Harry and Rebecca Timbres. Prentiss Hall, Inc., New York. \$2.50. 8 x 5½; xiii + 290; 1939.

It is difficult to appraise such a book as this. Harry Timbres did not go to Russia to gather material for a book, or to study sociological phenomena, or to spread propaganda. He went only to render service, and he was one of those peculiar people to whom service is a sacrament.

During the world war the Russian people had had to fight three wars simultaneously—a foreign war against the central European powers, a revolutionary war against the government that had oppressed them and lived off of them parasitically through several centuries, and a civil war against certain of their own leaders who sought to betray them. Victory was finally achieved, but at a terrible cost, which was both physical and spiritual. Then came the blockade, bringing famine and pestilence in its wake.

Into such a scene of devastation as this Harry Timbres felt the concern to go to minister to the victims of the war system. The locality which he selected for the site of his labors was about half way between Moscow and the continental divide. Here

at Marbumstroy he settled in 1937, here he was joined later by his wife and two children, and here he laid down his life within a year, a victim of exanthematous typhus.

The book is the story of the experience of this family pursuing the task of their choice. It was not written to arouse either passion or compassion, but simply to tell what they saw and lived through. The story is related by Rebecca Timbres, for Harry spent all his time after completing his routine at the hospital and laboratory each day in translating medical works into Russian from English, and had no opportunity for original literary activity. Those of his letters which are reproduced have of course not been edited in anyway, and are largely taken up with personal matters of technical detail, that might better have been omitted. But Rebecca's journal is an interesting and significant document, dealing as it does with experimental altruism based on individual initiative. It tells us nothing about the politics or economics of Russia in the mass, but it does tell us what individual Russians think, how they live, and what they do.



CULTURAL RELATIONS ON THE KANSU-TIBETAN BORDER.

By Robert B. Ekvall. *University of Chicago Press, Chicago.* \$1.50. 9½ x 6½; xiii + 87; 1939 (paper).

The author was born on the Kansu-Tibetan border, lived there most of his first fourteen years, return in 1923 as a missionary, and remained there until 1935. His work brought him into close contact with the interesting ethnic groups (Chinese, Moslems, and Tibetans) of this little-known marginal area. Fortunately, the author's excellent memory, acute observations, and ability to present in clear concise manner a mass of detail without losing sight of the more generalized aspects of life on the border have combined to produce an excellent study of inter-ethnic relationships.

Although Ekvall divides the ethnic groups into Moslem, Chinese, and Tibetan, the last named is actually divided into two—the sedentary and the nomadic

Tibetans—one racial group presenting two different cultures. These four major groups are described in the following relation to each other: (1) the Chinese and the Chinese-speaking Moslems; (2) the Chinese and the sedentary Tibetans; (3) the Moslems and the nomadic Tibetans; (4) the sedentary and the nomadic Tibetans. Between the Chinese and the Moslems (an Arab-Chinese race worshipping Islam) there is hostility due to racial, religious, and personality differences; between the Chinese and the sedentary Tibetans there is an infiltration of ideas and customs with the result that many Tibetan villages have become Sinicized; between the Moslems and nomadic Tibetans there is a mutual diffusion of traits brought about by constant trade relations and economic usefulness to one another; between the sedentary or agricultural and the nomadic or pastoral Tibetans—people actually of the same race and religion (Buddhism) but of different occupations—there is a marked social differentiation with the nomads in the ascendancy.

The study is most interesting for the light it throws upon these little-known races—their modes of subsistence, racial differences, religious differences, language, customs, ethnic heritages, numbers and vitality of population, warfare, economic organization, and their inter-ethnic relations. A problem of especial interest to students of population would be the markedly high birth-rate of the Chinese in definite contrast to the other three groups.



POPULATION AND PEACE. *A Survey of International Opinion on Claims for Relief from Population Pressure.* *International Studies Conference.*

By Fergus C. Wright. *International Institute of Intellectual Co-operation, Paris; Columbia University Press, New York.* \$2.00. 9½ x 6½; xvi + 373; 1939.

This work deals primarily with peace, and with population only insofar as it affects peace. In its method of approach it has more in common with Henri Van Etten's *Pax Oeconomica* (which discusses peace but not population) than with

Carr-Saunders' *World Population; Past Growth and Present Trends* (which discusses population but not peace) despite the fact that Carr-Saunders is quoted over 500 times and Van Etten not at all. The rapidity with which political history is developing is indicated by the discussion of population problems in Austria, Czecho-Slovakia, and Poland, which no longer exist as sovereign states.

According to the findings of the Committee which prepared this book, the only countries in which overpopulation is likely to lead to war are Germany, Italy, Japan, and Poland. In the first of these the process of industrialization has been completed, and the need for colonies to which the surplus population may be exported is acutely felt. Of course there have been many underpopulated nations that have been glad to accept German immigrants in the past as rapidly as they could be assimilated, but present day Germany does not want her emigrants assimilated, she wants them to surrender their residences in Germany but to retain their allegiance to the German flag. The industrialization of Italy and Japan have been only partly accomplished and its continuance will care for the increasing population of these nations for some years to come. But industrialization calls for raw materials, and the conquest of Ethiopia by Italy was intended to supply to the latter a region thought to be rich in natural resources. The great need of Japan is not raw material but markets for finished products, and the densely populated Korea and Manchukuo met this need much better than a sparsely populated region (for example, Australia) ever could have done.

From these considerations it appears that there can be no panacea for relief from population pressure, but that each case must be dealt with separately. The International Studies Conference of the League of Nations to whose researches this book is due have been seeking for four years to learn which nations are suffering from this complaint, to what extent, and what palliative measures may be applied; but they have formulated only a very fragmentary answer to these questions.

The book has 36 pages of bibliographic references, but only 10 of index. Incidentally it is not made clear why Japan and Germany continue to be represented on the Committee after their withdrawal from the League.



SOME MEMORIES OF A PALAEONTOLOGIST.

By William Berryman Scott. Princeton University Press, Princeton. \$3.00. 9 x 6; [7] + 336; 1939.

The author of this work celebrated his 80th birthday in 1938. The book is the story of a long and interesting life that began back in the pioneer days of American science and has continued active up to the present. All the leading intellects of the world not only in paleontology but also in other fields of biology and geology parade in orderly fashion across the pages of this remarkable book—Ameghino and Moreno of Brazil; Gegenbaur, Bütschli, His, Zittel, and Weismann of the German Empire; Milne-Edwards of France; Huxley, Tyndall, Owen, Woodward, Balfour, Sedgwick, Lankester, Mosely, Thompson, Geikie, and Bateson of Great Britain; Dawson of Canada; as well as the Americans Leidy, Cope, Marsh, LeConte, Dana, Gray, Henry, Young, Mitchell, Keen, Merriam, Dall, Ortmann, and Scott's most intimate friend from college days on, Henry Fairfield Osborn. Scott regarded Cope as perhaps the greatest genius he ever met. He adds some more matter, useful for the record, to the account of that remarkable person Othniel C. Marsh, but it becomes increasingly clear that the whole story will never be told in print. Both Osborn and Scott, who probably knew more about it at first-hand than anyone else, suffered from the inhibitions that are associated with being gentlemen, and in their autobiographies exhibit a reticence at certain points that does credit to their humanity, but demonstrates once more that the history of scientific matters is no more likely to be written with scientific precision and completeness than is any other kind of history.

Scott's career is one of great significance, and it is to be hoped that some day his life will be written as it deserves to be, for

he was too close to himself to view himself in the proper perspective. When that time comes the present work will be an excellent source of material, for it is rich in reminiscences of fossil hunting expeditions to the Middle West in which a loquacious nephew of Jim Bridger figures prominently, of years spent in study at Heidelberg, of conventions of the world's leading scientific organizations, and of social contact with men of letters like Charles Godfrey Leland, John Bach McMaster, James Bryce, Oscar Wilde, Jules Jusserand, and Woodrow Wilson. There is an index of 14 pages.



LESTER F. WARD, THE AMERICAN ARISTOTLE. *A Summary and Interpretation of His Sociology.*

By Samuel Chugerman. Duke University Press, Durham. \$5.00. 9 x 6; xiii + 591 + 4 plates; 1939.

The stated purpose of this book is to rescue the memory of Lester F. Ward (1841-1913) from the neglect of the present generation of sociologists. The aim is laudable because Ward was undoubtedly a man of superior intellect. He occupied a high position among paleobotanists, possessed a unique command of scientific terminology and was accepted as a foremost student of sociology when this branch of learning first began to separate from the metaphysical trunk to which it is still closely adherent. As a sociologist Ward was actually a follower of Comte pleading for a new social order along the lines of the Platonic Republic. Pitted against the teachings of Sumner, Ward's feeble and naive attempts at social welfare never advanced far and at his death were more or less immediately forgotten. Chugerman believes that this state of things should be remedied and in one swoop raises him to the intellectual Olympus along side of Aristotle, Darwin, Kant and similar ranking gods. The reason why Ward should occupy such an elevated position is never made clear. The major portion of the book's 600 pages consists of a short biography of our hero, many pages of laudatory adjectives, a critique of the outstanding sociologists and an

attempt to find an important place for Ward in the history of human thought. Since the author prefers to tell the reader of the greatness of Ward rather than to demonstrate it he is not quite convincing, particularly when he chooses examples of Ward's profound *dicta* such as these: "Matter is what it seems to be" or "1. The object of nature is function. 2. The object of the organism is desire. 3. The object of evolution is activity. 4. The object of man is happiness. 5. The object of society is achievement." The author's wholehearted devotion to his cause is praiseworthy but he would have rendered more effective service to his idol had he controlled the verbal manifestations of his sentiments and proceeded to a sober evaluation of Ward's contributions.



PRIESTS OF LUCINA. *The Story of Obstetrics.*

By Palmer Findley. Little, Brown and Co., Boston. \$5.00. 9½ x 6½; xiv + 421 + 32 plates; 1939.

The *Priests of Lucina* is a study of childbirth, medical obstetrics, and midwifery from earliest times on. The author begins by discussing the anatomical proportions of the Venus of Willendorf and "the obstetrical difficulties that must have beset our paleolithic mothers" if this distorted figure were at all representative of prehistoric women. Next are considered the obstetrical practices in the ancient Orient, the fertile land of Mesopotamia between the Tigris and Euphrates Rivers, Egypt, in ancient Judea with its Mosaic laws, Persia, India, China and Japan. From this point on the author treats the history of childbirth and the practice of obstetrics as a history of biographies. The first biography is that of Hippocrates, the star of the Golden Age of Greece, and the last, of John Whitridge Williams, a name revered in the annals of the Johns Hopkins Medical School. A chapter of outstanding interest is that on the Chamberlens and the manner in which they guarded the secret of the "iron tongs", the obstetrical forceps, and the many ways in which they antagonized the College of Physicians from which almost every member of four generations of Chamberlens was expelled

for infraction of one rule or another. "It would appear that the practice of fee splitting is not, as we think, a modern invention, for we find Dr. Peter Chamberlen charged with subsidizing the midwives in lieu of their patronage by offering to build alms houses for 'decayed midwives' and by feasting them with venison, wine and other delicacies." (17th Century.)

The second part of the book consists of studies on the five following subjects: (1) Anatomy, (2) The Forceps, (3) The Midwife, (4) Puerperal Fever, (5) Cesarean Operation. An extensive bibliography and 38 excellent illustrations are included in this study.



CHILDREN OF GOD. *An American Epic.*

By Vardis Fisher. Harper and Bros., New York and London. \$3.00. 8½ x 5½;

[8] + 769; 1939.

Here is the story of the Mormons—one of the strangest phenomena of human group biology in all history—told with all essential detail, and authoritatively. The author is of Mormon descent on both sides, his father having been the first settler in the upper Snake River Valley, where he was sent by the Mormon Church to start a colony. Naturally the Mormon philosophy and point of view get sympathetic exposition throughout. At the same time the comic elements that were the ineluctable concomitants of so much sincere earnestness are in no way glossed over. A great part of what is funny about Mormonism and the Mormons came into the picture through Joseph Smith, surely as comic a character as is to be found in all history. Grading A in the truly irresistible combination of humorlessness and concupiscence, and not too queasy about standards of integrity in matters of conduct, he was plainly foreordained to be a religious leader.

With all due admiration for the sterling qualities of the rank and file of the pioneering Mormons, and most of their leaders including especially Brigham Young; and in face of the fact that in the end the whole affair worked out pretty well; the story is nevertheless depressing. It is depressing because it depicts so clearly the ineradicable folly of mankind. How *could* other-

wise sensible human beings take seriously the transparently silly rumble-bumble of Joseph Smith? And on the other side, how *could* the people of the United States, and those responsible for the government of the country at the time, treat the Mormons so badly as they did?

The book does not seem to us to rate anything like as high as literature as it does as history. It is too repetitious and tediously verbose. But, at that, it will be a mistake not to read it.



GREENLAND JOURNEY. *The story of Wegener's German Expedition to Greenland in 1930-31 as told by members of the expedition and the leader's diary.*

Edited by Else Wegener with the assistance of Fritz Loewe. Translated from the 7th German edition by Winifred M. Deans. Blackie and Son, London and Glasgow. 12s. 6d. net. 8½ x 5½; xx + 295 + 47 plates; 1939.

This is the story of the German expedition of 1930-31 to the Greenland ice-cap, planned and led by Alfred Wegener, who died on the ice in the late autumn of the first year, presumably from the failure of an overstrained heart coupled with severe exposure. The primary objectives were geophysical, especially in the realm of glaciology, and climatological. The planning was thorough, and took advantage of much of the wisdom accumulated by the experiences of earlier polar explorers, as well as all the aids that accrue from the development of modern science. But in spite of all this the enterprise did not go well in actual fact. It is not the place here to go into any discussion of the reasons for the succession of mishaps. In spite of the troubles and difficulties the scientific results achieved were more than respectable, both as to quantity and quality. And this popular account abounds in thrills—in fact there were rather more thrills than modern explorers regard as consistent with really well-executed operations in the polar field.

Of specifically biological interest, and also the high point of the enterprise from all points of view, is the account of the winter at *Eismitte*, the station on the

ice-cap at about the center (east and west) of Greenland, where three men lived and made daily observations. Their supplies were inadequate; one of them had to have his frozen and gangrenous toes amputated without benefit of either surgeon, proper instruments, or anesthetic. The Greenland ice-cap in winter must come close to being the world's worst environment for the sustaining of life.

The book is well illustrated, but lacks an index.



TIME-BUDGETS OF HUMAN BEHAVIOR. *Harvard Sociological Studies Volume II.*

By Pitirim A. Sorokin and Clarence Q. Berger. *Harvard University Press, Cambridge; Oxford University Press, London.* \$2.50. 8 $\frac{1}{2}$ x 5 $\frac{1}{2}$; xi + 204; 1939.

This volume embodies the results of a unique investigation on some of the specific activities that constitute human behavior. The main problems with which the study is concerned relate to the kind, frequency and duration of activities that occupy the individual's day, the motivation of the activity, the social elements involved and the influence of sex. The material consists of the systematic records of the activities of almost 100 persons who themselves noted their daily actions for a period of four weeks. The results indicate that in terms of time consumed those activities relating to pleasurable, societal, economic, and physiological needs are the most important; while in terms of the number of persons participating, first place is taken by actions related to physiological needs and then follow those involving economic and societal manifestations. These findings are particularly significant as a demonstration of the multiplicity of factors affecting human behavior and of the importance of those factors that may be called elemental or biological. However, the most interesting aspect of the present investigation regards the analysis of the motivations adduced for the several activities. The most important of all motives is found to be personal comfort, next comes the strictly social motive, while the least frequent appear to be actions based on religious,

moral, and legal reasons. These observations reveal clearly the inadequacy of theoretical formulations about social behavior and strongly point to the need for more concrete information about what man actually does and why. The present study represents a successful step in that direction.



MAN THE SLAVE AND MASTER. *A Biological Approach to the Potentialities of Modern Society.*

By Mark Graubard. *Covici Friede, New York.* \$3.50. 9 $\frac{1}{4}$ x 6; 354, 1939.

This is a much better book than the rather weak and lukewarm blurbs on the cover would indicate. It is an effort to inaugurate a development of socialism and the social sciences generally that shall be parallel to that now being undergone by psychology, and like it based upon a sound biological foundation.

The author is a thorough going iconoclast, and breaks lances with practically every other modern writer in defense of his own personal philosophy, which he calls scientific humanism. The choice of terminology is unfortunate, for it has little in common with the half dozen or so philosophical systems bearing the same name, which have enjoyed brief periods of efflorescence since the time of Erasmus and which have since disappeared because they lacked strength sufficient to support their own weight. But the philosophy enunciated in this work is thoroughly sound although it contains nothing new. He attacks organized religion while subscribing to many of its tenets.

The author's literary style suggests the exuberance of youth. The verb "to sculpt" fills a long felt need in the English language. (Is this word the invention of the author? It is not in the reviewer's dictionary.) The use of the perfect passive participle of "taboo" in its correct form is to be commended, but the use of "Slovakians" for "Slovaks" is not so happy.

The index covers only five pages, but this is adequate for a popular exposition such as this.

FRONTIERS OF ENCHANTMENT. *An Artist's Adventures in Africa.*

By W. R. Leigh. Simon and Schuster, New York. \$3.00. 9 x 6; xi + 299, 1938.

The author, an American painter well known for his realistic portrayals of the out-of-doors, writes in this book of two African expeditions on which he went in the capacity of painter for the American Museum of Natural History of New York. The first expedition was headed by Carl Akeley, great naturalist-artist, the practical visionary who first conceived the idea of building African Hall in the Museum of Natural History, famous taxidermist and inventor, author of *In Brightest Africa*, and one of the pioneers in the field of habitat-grouping. It was on this expedition, November 17, 1926, that Carl Akeley died and was buried in the land he loved so dearly. After his death his wife headed the expedition and completed the work which her husband had planned. The author's work on this first expedition as on the second, the Clark-Carlisle Expedition, was that of painting "with perfect fidelity to nature" natural backgrounds for habitat-groups. Wherever he journeyed he painted not the Dark Continent but a glorious, sunbathed, enchanting Africa; not a country of pestilential swamps and jungles but a land of varying natural scenic beauty. In his book Leigh tells of his two expeditions to Africa and manages to convey to the reader, as few writers have before, the "feel" of Africa, an understanding of its animal life and of its wild, virgin beauty. The volume is profusely illustrated with original sketches.

**ARCTIC AND ANTARCTIC.** *The Technique of Polar Travel.*

By Colin Bertram. W. Heffer and Sons, Cambridge. 7s. 6d. net. 9½ x 6½; xii + 125 + 12 plates; 1939.

This book is different from the usual run of polar travel stories which cite the adventures of a single journey. Appropriately enough the first chapter is entitled "Why?" Why do men go on polar expeditions? With advancing years the reason

has changed. It is now largely scientific research—the desire to know. As the principal environmental factor encountered in polar regions is cold a number of pages are devoted to the biological effects, on mind and body, of decreased temperature. Clothing, tents and food are dealt with as methods of combating cold. The subject of food, particularly on sledging journeys, is of great importance. In this matter as in that of clothing, recent expeditions are much superior to those of years ago. Not only do the modern rations weigh 25 percent less, but they are definitely better in nutritional value.

One of the greatest problems of polar travel is the type of motive power to be used. The reindeer, the pony, and the mechanical tractor have been tried with mixed success and failure. Man-power and dog-power have proved most efficient, depending upon conditions of the terrain. A multitude of details explain the outfitting of sledging parties, and finally, the writer waxes eloquent over the beauties and calm of polar lands, and the indescribable something that draws explorers away from the activity of civilization.



THE NATIVE RACES OF AUSTRALASIA including Australia, New Zealand, Oceania, New Guinea and Indonesia. *Anthologia Anthropologica. A Copious Selection of Passages for the Study of Social Anthropology from the Manuscript Notebooks of Sir James George Frazer.*

Arranged and Edited by Robert A. Downie. Percy Lund Humphries and Co., London. 35 s. 11 x 8½; vi + 390; 1939.

The size and numbers of the accounts in this huge volume containing passages from Sir James Frazer's notebooks are apt to frighten the would-be student of social anthropology. Even the most serious student is somewhat appalled at his own insignificance when he considers the statement of the editor that "This volume contains, in the main, material that Sir James has not used in his published works" and then thinks of the prodigious number of books the author has already produced.

The volume is concerned with a very

small portion of the terrestrial globe—merely Australia, Tasmania, the Polynesian group including among other places New Zealand and the Hawaiian Islands, Micronesia including Formosa and the Philippines, Melanesia including the Fiji Islands and Solomon Islands, New Guinea and the Torres Straits, and Indonesia, in which last group Borneo, Bali, Java, and Sumatra are a few of the places considered. Detailed and numerous passages on the customs and observances of the diverse races of primitive folk of the South Seas are herein presented as first-hand accounts without further explanation. Any interpretation to be made of these facts is left for the reader. An index and five simply outlined maps should aid the student of social anthropology through this ponderous assortment of manuscript notes.



RED STRANGERS.

By *Elsperth Huxley*. Harper and Bros., New York and London. \$2.50. 8 x 5½; viii + 406 + 16 plates; 1939.

Although set in the form of a novel—and an entertaining and moving one—actually this volume furnishes in popular form a sound and detailed account of the general and cultural anthropology, as well as the social history over two complete generations of a branch of the Kikuyu people inhabiting the South Nyeri district of the Kikuyu reserve located on the southern slopes of Mt. Kenya in East Africa. It gives a clear picture of the psychological stresses and strains, both individual and social, that accompanied the contact of a native tribe possessing a rather highly organized social structure with the invading whites of the modern world—the Red Strangers. The eventual and inevitable outcome was, of course, the complete subjugation of the blacks, spiritual as well as physical and material. The account makes it clear that, on the whole, the procedures of the whites were as gentle, kindly, and intelligent as could have been expected in the circumstances. And there is no reason to doubt the substantial truth of the impression so conveyed. Yet the net result was to reduce a happy and up-standing people, thoroughly well adapted

to an environmental scene to which they had long been accustomed, to a pitiable state. There is apparently no question of the continued survival of the Kikuyu, in the biological sense. It is merely that they will survive as a different sort of human beings.

We recommend this book strongly. It represents an inherently difficult job of writing extremely well done.



TO THE LOST WORLD.

By *Paul A. Zahl*. Alfred A. Knopf, New York and London. \$2.75. 8 x 5½; x + 268 + 16 plates; 1939.

Although the author's expedition through the jungles of British Guiana had a scientific purpose—the finding and capturing of giant poisonous ants (*Paraponera* and *Dinoponera*) to take back to his laboratory at Harvard—this volume is mainly an adventure story and one which is truly exciting and excellently told. Besides the ants which he finally deposited alive before a bewildered customs inspector on a Boston dock, the author's main purpose was to visit the fabled Lost World on top of Mount Roraima far in the uninhabited interior of South America.

Dr. Zahl tells of the thrilling flight from Georgetown in a small hydroplane over dangerous jungles to a point where he and his companion, a gold and diamond prospector, engaged native guides and carriers and continued on foot and by canoe. During their wanderings through the jungle, the author in search of ants and his companion in search of diamonds, which he never found, they encountered natives who had never seen white men, they survived the flood of a tropical river, and visited the gigantic falls both of Kamarang and of the Uitschi, the latter over a quarter of a mile high. They found waterfalls hitherto unrecorded and withstood the dangers of snakes and malaria until at last they scaled the great height of Roraima itself. The volume should be completely enthralling to the adventure lover and to the scientist. The author's excellent and unusual photographs are particularly worthy of praise.

BLACK WORKERS AND THE NEW UNIONS.*By Horace R. Cayton and George S. Mitchell.**University of North Carolina Press, Chapel Hill. \$4.00. 9 x 6; xviii + 473; 1939.*

By means of numerous personal interviews the authors have inquired into the attitudes of the white worker, the labor union, and the employer towards the Negro worker and the latter's reaction towards the former. The investigation has been limited to three industries—iron and steel, meat packing, and railroad car shops. Both in the north and south the findings appear to be the same. On the part of the white worker there is overt antagonism of varying degree. This appears to be due in part to a persistence of racial intolerance and in part to fear that the Negro will supplant the white. There is some foundation for such fear since in the past the Negro was extensively used as a strikebreaker and in this fashion first made his appearance in Northern industries. The Negro in turn, being well aware of the attitude of the white worker, has reacted by suspecting the motives of his white colleague and has often refused to participate in labor movements. These findings would seem to indicate that among laborers one finds more or less the same barriers to social intercourse between white and Negro as is seen in the general population. This point is, however, not considered at any length by the authors who are more interested in arriving at some means of altering the situation. As a solution they advocate the organization of Negro labor unions which they believe would strengthen the position of the Negro with respect to both the white laborer and to the employer.

**THE STORY OF SURGERY.**

By Harvey Graham. With a Foreword by Oliver St. John Gogarty. Doubleday, Doran and Co., New York. \$3.75. 9 x 6; 425 + 24 plates; 1939.

Prehistoric skulls have been found which show definite evidences of trepanning, possibly for the release of demons from the body of the victim. Today, in hundreds of wonderfully equipped operating rooms, skilled hands are still struggling against

demons. This book is the fascinating story of the progress of surgical knowledge between these two ages. The author mentions other Neolithic evidences of surgery, and then discusses practices among the ancient Chinese, Egyptians, Greeks, and Romans. The art went into eclipse after this, save for a few hardy souls who carried on the teachings of Galen and Hippocrates. A renaissance took place several hundred years later, with the establishment of schools at Salerno and elsewhere in southern Europe. The next few centuries saw the lives of several individuals such as Vesalius, Paré, Clowes, and especially Harvey, who dared question the wisdom of the ancients.

Dr. Graham (a pseudonym) tells how, until the advent of anaesthesia about 1850, the greatest advances were made in the skill and rapidity with which limbs could be amputated or stones removed. After this, speed was no longer at a premium. A few years later came the greatest advance of all—antiseptic surgery. Tribute is paid to Joseph Lister in the story of his life. The book closes with a description of the status of surgery today, and what may be expected in the future.

Dr. Graham writes with all the skill of the dramatist, mingling grim pathos with keen humor. The story is highly recommended to student and layman alike.

**TEN YEARS UNDER THE EARTH.**

By Norbert Casteret. Preface by E. A. Martel. Translated and edited by Barrows Mussey. The Greystone Press, New York. \$3.00. 8½ x 5½; xx + 283; 1939.

Everybody has longed to view places never before seen by human eyes—ocean depths, polar regions, dense jungles, or underground caverns. One feels, as he reads this book, that he is with the author penetrating the mysteries of grottoes, and chasms. Swimming through submerged tunnels and forcing narrow corridors M. Casteret penetrates deep into the Pyrenees, entering large rooms rich in relics of ages past. He finds prehistoric hearths, flint tools, clay statues, and stone engravings mingled with bones of the now extinct animals with which cave dwellers

had struggled for supremacy. Much of the history of these men and animals is reconstructed from such findings.

Aside from the study of ancient remains, the writer has done valuable work in hydrographic surveying. This involved not only such matters of interest as determining the sources of rivers, but also finding methods of diverting streams for electrical power.

The book is written in an interesting manner, describing vividly all of the conditions met with in subterranean exploration. In some places the caverns are rank with thick slime and decaying carcasses; in others there are colorful frozen lakes, fantastic stalactites and stalagmites, or beautiful flowers of gypsum or other crystals. A section is included on the fauna of caverns. Speleologists and biologists generally will not be alone in enjoying this volume.



JOHN HOWARD (1726-1790) *Hospital and Prison Reformer: A Bibliography.*

By Leona Baumgartner. Introduction by Arnold M. Muirhead. The Johns Hopkins Press, Baltimore. \$1.00. 10 x 7; 79; 1939.

John Howard was nearly 50 years of age before he began the work for which he is known. Born in Clapton in 1726 he lived a life of easy routine until his appointment as high sheriff for Bedfordshire. In an attempt to find a precedent for the correction of certain prison abuses, he visited most of the prisons of England and Wales, but found none. The appalling conditions he did find though were carefully recorded in his notebooks. He spent the remaining 17 years of his life, and his fortune, in travel to every country of Europe to study conditions in prisons and lazarettos and died of "camp fever" while inspecting military hospitals at Cherzon, Russia. His two books *State of Prisons* (first edition, Warrington, 1777) and *Lazarettos* (first edition, Warrington, 1789), gave a tremendous, if not immediate, impetus to the improvement of prison and hospital conditions.

Dr. Baumgartner includes in this bibliography not only the editions and trans-

lations these two books have passed through, but also works edited by or attributed to Howard, contributions (4) to journals, biography and criticism, contemporary biographical notes and reviews, and unpublished letters. The items are accompanied by interesting notes and in most cases libraries having copies are noted. Dr. Muirhead who acquired the Collection of Howardiana, now in the Library of Dr. John F. Fulton at Yale University, contributes a biographical account of the life and work of Howard.



METHODIK DER VÖLKERKUNDE.

By Wilhelm Mühlmann. Ferdinand Enke Verlag, Stuttgart. RM. 14. (paper); RM. 15.80 (cloth); (25 percent less outside of Germany). 9½ x 6½; viii + 275; 1938.

The spirit of this treatise is essentially emotional. The writer desires a return to ethnology based upon German eighteenth century romanticism. At that time the subject was based upon sophistry and conclusions were drawn from inward feelings.

The writer draws upon a large volume of English, French, and German literature. He endeavors to show that the physical and cultural attributes of men vary among different races. Those races which have developed characteristics giving to them a higher survival value will ultimately become the rulers of less progressive nations. It is an attempt to apply the biological principles of Darwin's natural selection hypothesis to the field of ethnology. It is also pointed out that ethnology is no longer to be regarded as a "pure science" but is to be used as a means of establishing a better science of life among individuals in the superior race.

The opus contains an extensive bibliography, and subject and author indexes.



THE CAMEROONS AND TOGOLAND. A Demographic Study.

By Robert R. Kuczynski. Oxford University Press, London, New York and

Toronto. \$10.00. 9½ x 6½; xviii + 579 + 3 maps; 1939.

This is the first attempt to assemble all the essential facts relating to the collection of population statistics and to the demographic situation of an African area from the beginning of its colonization up to the present time. It is the first part of an analysis which is eventually to be extended to include the Union of South Africa, the Belgian Congo, French West and Equatorial Africa. The West African Mandated Territories were studied first for two reasons: three great Powers, each following a different colonial policy, have participated in their administration; and more ample sources of information were available concerning them, since they were subject to a mandate conferred by the League of Nations. The data for each Territory is treated separately, under each stewardship (German, French, British).



POVERTY AND POPULATION. *A Factual Study of Contemporary Social Waste.*

By Richard M. Tismuss. The Macmillan Co., New York and London. \$3.50. 7½ x 5½; xxviii + 320; 1938.

That poverty is associated with a high mortality from certain diseases is such a well-known fact that a book describing it would *ipso facto* be considered superfluous, particularly when nothing new is brought out regarding the significance of the association. However, the author's presentation of the English mortality statistics according to geographic regions has for its purpose to emphasize a condition to which insufficient attention has apparently been paid by the powers that be. For some time now, the North of England and Wales have gone through a marked economic depression and there one finds the highest mortality from all causes, from tuberculosis, from puerperal diseases, and from those of infancy, in particular. Furthermore, the decline in mortality noted in the country as a whole has proceeded in these regions with the lowest decrement. The author pleads that something should be done about it, and aside from all humanitarian considerations his

simple array of the facts should prove very effective towards this end.



A GUIDE TO ALASKA. *Last American Frontier.* John W. Troy, Governor of Alaska, Sponsor.

By Merle Colby. The Macmillan Co., New York. \$3.00. 8 x 5½; lxv + 427 + 64 plates + 2 maps; 1939.

The general purpose of the American guide series is to give to Americans a detailed portrait of their country and all its outlying possessions. This volume fulfills its purpose adequately, giving a complete picture of one of our greatest land possessions, namely, Alaska. It gives all the answers to all the questions that an American tourist in Alaska could possibly ask. Included are notes on the history of the discovery and development of Alaska; its purchase by the United States from Russia; its people; its means of transportation and communication; its industries; its points of interest; its climate and its geography. In fact, all that a tourist needs for making the trip to Alaska is this guide, the money, and the inclination to go!

Many illustrations, both graphic and photographic are used to depict the homes, surroundings, and activities of the inhabitants of Alaska. Included also are numerous maps, and a complete index.



RACE RELATIONS AND THE RACE PROBLEM *A Definition and an Analysis.*

Edited by Edgar T. Thompson. Duke University Press, Durham. \$3.50. 9 x 6; xv + 338; 1939.

Eight sociologists, an anthropologist and a zoologist—all leading figures in their respective fields—have contributed to this discussion of the problem of intercourse between different racial groups. Almost all the articles are concerned with some aspects of the relationship between Negroes and whites, especially in the south. The articles deal with the differences between the Negroes and whites with respect to natality, mortality, social and economic status, and the kinds of

social relations existing between the two groups. In general the authors stress the question of racial intolerance, the inferior position in which the Negro is held and the probable complications in the Negro-white relations that may arise in the future. In this respect no solution is offered. Although lacking originality with respect to both ideas and discussion, each of the articles represents a scholarly review of the subject treated.



LABOR POLICY UNDER DEMOCRACY. *University of Colorado Studies. Series C. Studies in the Social Sciences, Vol. 1, No. 1.*

By Clay P. Malick. *University of Colorado, Boulder, Colo.* \$1.00. 10 x 6½; 130; 1939 (paper).

This thorough and comprehensive work is a study of institutions designed to promote industrial peace. The author discusses the democratic state and the significance of government interference and suggests that an adequate method of industrial peace must embody three fundamental principles: The need for strong organizations to represent the interests of employers and employees; legal recognition and enforcement of their collective agreements; and, finally, appropriate agencies for adjusting their differences and for supplying sanctions to the arrangements adopted by them. In addition to the chapter on labor laws in the United States, chapters are also devoted to conciliation in Great Britain, the law of labor in Weimar, Germany, and compulsory arbitration in Australasia. Bibliographic footnotes supplement the pages.



TRACKS IN THE SNOW.

By David Haig-Thomas. *Oxford University Press, New York.* \$3.00. 8 x 5½; 292 + 16 plates; 1939.

In this swift moving drama of the north, the reader is carried right along with the explorer, sharing all the thrills and hardships that are a part of a journey in the polar region. As the author himself states, the purpose of the journey was never realized, yet one wonders whether

his observations of the northern flora and fauna, and his intimate association with the Eskimos are not as valuable in the world of science as would have been the mapping of a few far-off, little-known frozen pieces of land. A picture is given of the absolute ruthlessness of nature in the far north, and of the struggle for existence of the few forms that have selected this cold and frozen waste as their native habitat.

The book is well supplied with photographic illustrations of the animals, plants and people of the region. Several line maps show the areas traversed by the author and his party.



RACES OF AFRICA. *Revised Edition.*

By C. G. Seligman. *Thornton Butterworth, London.* 2s. 6d. net. 6½ x 4; 255; 1939.

This little volume (first edition appeared in 1930), issued in the Home University Library Series at a low price, is interesting reading. An authority on ethnology, Seligman has produced a well-rounded picture of the races of Africa, discussing them both from the anthropological and ethnological points of view, in simple non-technical language. The lay reader with an interest in racial studies will derive much pleasure from this book. It would seem to be well-nigh imperative reading for those desiring a comprehensive understanding of the problems with which present-day Africa is confronted. A number of distribution maps are included in the volume, a list of literature, and an index.



RASSENBIOLOGISCHE UNTERSUCHUNGEN aus dem hygienischen Institut der medizinischen Fakultät zu Kanazawa. Number 7.

Edited by Y. Koya. *Hygienisches Institut an der medizinischen Fakultät, Kanazawa, Japan.* 10½ x 7½; 272; 1939 (paper).

This volume contains a series of papers based on anthropological measurement and growth studies, for the main part on Japanese populations. The first paper, on

the Hida inhabitants, is presented in both German and Japanese by Y. Kato; those on constitutional findings among Japanese school-children, by Y. Koya and T. Takabatake, and anthropometric investigations on the Marshall Islands, by M. Samejima are in German. The last contribution, by T. Takabatake, Y. Kato and T. Fukuda, is a series of tables showing relative head breadths and head lengths. Y. Kato and N. Fukuda are in German. The other contributions are in Japanese but the extensive tabular material is supplied with German headings, thereby making them understandable to readers not familiar with Japanese.



SCIENCE AND SOCIAL CHANGE.

Compiled by Jesse E. Thornton. The Brookings Institution, Washington, D. C. \$3.00. 9 x 6; xi + 577; 1939.

This volume contains reprints of approximately fifty papers dealing with some of the aspects of the interrelationships among such fields of intellectual endeavor as biology, engineering, economics and sociology. Included are extracts from the writings of learned men from Karl Pearson and Robert A. Milliken to Walter Lippman and Waldemar Kaempffert. In the majority the articles are products of modern writers, but a few classics, John Stuart Mill for example, are also represented. This anthology may prove useful as a source of quotations for the persons who are overtly preoccupied with the influence of science on society but in general the articles contribute very little to an elucidation of the problem.



FACES WE SEE.

By Mildred G. Barnwell. Southern Combed Yarn Spinners Assoc., Gastonia, N. C. \$3.00. 11 x 8½; 112; 1939.

Many people have thought that southern cotton-mill workers live amidst backwoods squalor. It is to banish this idea that this book has been published. Most of the pages are devoted to photographs showing mill folks at work, at school, at home and at play. Interspersed are de-

scriptions of family life, with particular emphasis on the financial status of these people and its vast improvement within recent years. "Steady employment, good wages, ample leisure time, pleasant community life have made of cotton mill workers a people of integrity and character who lead simple, normal American lives, who wonder what part of the South folks are talking about when it's called Economic Problem No. 1."

[Reginald, the Office Boy, who is getting so leftish that he walks sidewise like a crab, says that it is a devil of a note that nobody around this office can spot capitalistic propaganda even when it stinks.]



FAMILY INCOME AND EXPENDITURES. Pacific Region. Part I, Family Income. United States Department of Agriculture Miscellaneous Publication No. 339.

By Day Monroe, Marjorie S. Weber, and Helen Hollingsworth. U. S. Department of Agriculture, Washington, D. C. 35 cents. 9½ x 5½; iv + 380; 1939 (paper).

This study was undertaken in 1936 to provide comprehensive data on the way American families earn and spend their incomes. Part I of this report presents data on the income for the native-white unbroken families studied in small cities and villages in the Pacific States. Part 2 deals with the distribution of total expenditures, and the relationship between income and expenditures. Over half the study is devoted to appendices which include all the factual data in table form.



RUNNER OF THE MOUNTAIN TOPS. The Life of Louis Agassiz.

By Mabel L. Robinson with decorations by Lynd Ward. Random House, New York. \$3.00. 8½ x 5½; [12] + 290 + 8 plates; 1939.

This is the very beautiful story of the life of a great man, told for children by one who knew him personally. It is illustrated with colored plates from Agassiz's works, but there is no index and no documentation. The brief bibliography includes such items as Longfellow's and

Whittier's poems, but it omits the appreciative interpretation by Le Conte.



MAN MAKES HIMSELF.

By V. Gordon Childe. Oxford University Press, New York. \$1.75. 7 $\frac{1}{2}$ x 5; xii + 275; 1939.

This is an American edition of a well-known work first published in England several years ago and reviewed in these columns in Vol. 12, No. 2, p. 218. The two editions do not appear to differ in any way.



ZOOLOGY

FIELD BOOK OF ANIMALS IN WINTER.

By Ann H. Morgan. G. P. Putnam's Sons, New York. \$3.50. 6 $\frac{1}{2}$ x 4; xv + 527 + 26 plates; 1939.

This excellently prepared little volume is the result of many years of keen field observation and painstaking compilation of data regarding all forms of animal life in their struggle to survive the rigors of winter weather. A large number of invertebrate as well as vertebrate organisms are followed through their winter cycle of activity, and the story of their mode of survival from early winter to late spring is told. The author has tirelessly tracked down even the smallest insects to find out something about their winter habitats, their economy, their latest fall and earliest spring activity, and their ways and means of setting up in the business of replenishing their kind for the next season.

There is an abundance of illustrative material, both graphic, photographic, and in color plates. A number of charts showing seasonal cycles of habitat, food, and activity have been included. The list of references for each chapter (each dealing with a single phylum) and the complete index add value to the book as a reference or field guide. The volume will undoubtedly find its way into the hands of a variety of professional and lay users, including the professor of natural history or zoology, the hunter, the trapper, or even the high school boy and girl who

have an interest in the living things about them.



NOMENCLATOR ZOOLOGICUS. *A List of the Names of Genera and Subgenera in Zoology from the Tenth Edition of Linnaeus 1758 to the End of 1935.* Vol. I. A-C.

Edited by Sheffield A. Neave. The Zoological Society of London, London. Subscription price for the complete work of four volumes, 8 guineas, post free. 9 x 6 $\frac{1}{2}$; xiv + 958; 1939 (paper).

This is an attempt to list alphabetically all the generic names published from the tenth edition of the *Systema naturae* of Linnaeus down to the present day. The editor states in his preface that there are 225,000 entries, and by making allowances for alternative spellings and cross references this number may be reduced to 192,000.

The reviewer who contemplates a work of this magnitude can sympathize with Xerxes standing beside the Hellespont, who is reported to have wept because out of his army of over two million not one would be alive at the turn of the century. Similarly this work will be out of date before it is printed, for the modern army of systematic zoologists are using mass methods of production to encumber the literature of the science with new generic terms at the rate of four or five a day. What systematic science needs is a *Nomenclator* that shall be issued periodically, reporting all new names, and perhaps publishing synonymies and other helpful matter. Such a work might obviate the nuisance of authority citations, by substituting a reference to the issue of the *Nomenclator* in which the name appeared.

This work should earn the undying gratitude of all systematists who take nomenclature seriously.



FOOD OF GAME DUCKS IN THE UNITED STATES AND CANADA. *United States Department of Agriculture. Technical Bulletin No. 634.*

By A. C. Martin and F. M. Uhler. United States Department of Agriculture, Wash-

ington, D. C. 40 cents. $9\frac{1}{8} \times 5\frac{1}{2}$; 157 + 153 plates; 1939 (paper).

FOOD HABITS OF NORTH AMERICAN DIVING DUCKS. *United States Department of Agriculture. Technical Bulletin No. 643.*

By Clarence Cottam. *United States Department of Agriculture, Washington, D. C.* 30 cents. $9\frac{1}{8} \times 5\frac{1}{2}$; 140 + 10 plates; 1939 (paper).

Both of these bulletins are based on material from stomach analyses made by the Biological Survey for the past half century. Widespread increase of interest on the problem of duck conservation and restoration has created a demand for knowledge of the food habits of these birds. The first bulletin supplies statistical data on the types of plants consumed. Each plant is described and its range pictured on a map of North America. Identification of the plants is simplified by the inclusion of 153 plates. The propagation and culture of these duck foods for depleted areas and new refuges is also included.

The second bulletin gives the food habits of each duck (except the mergansers), which includes the method of feeding, types of food chosen, food of adults and juveniles, etc. Both of these volumes provide all the necessary information for a sound conservation and restocking program.



PRINCIPLES OF FOREST ENTOMOLOGY. *Second Edition.*

By Samuel A. Graham. *McGraw-Hill Book Co., New York and London.* \$4.00. 9 x 6; xvi + 410; 1939.

This book, in which emphasis is placed on the influence of insects on the forest rather than on the insects themselves, first appeared ten years ago (cf. Q.R.B., Vol. IV, p. 577). Even within such a relatively short period as this it may happen that insects that were once pests have lost their foothold and have either dropped into obscurity or have become innocuous while the formerly unimportant or unknown insects have become widespread pests. The author's main approach, as in the earlier volume, is through a consideration of general underlying principles selecting certain insect species to illustrate how

these principles apply in individual instances." Whenever necessary, sections have been revised, new information is given on various forest insects which have recently become economically important. The chapter on insect abundance and the sections on termites and on bark beetles have been almost entirely rewritten, and the bibliography revised and extended.



OUR SMALL NATIVE ANIMALS. *Their Habits and Care.*

By Robert Snedigar. *Random House, New York.* \$2.50. $8\frac{1}{2} \times 5\frac{1}{2}$; [10] + 308 + 16 plates; 1939.

Most of us have the desire to keep some animal as a pet. Wild animals would frequently be welcomed instead of the usual domesticated kinds but for the fact that they apparently are so hard to keep. Actually their care is no more involved than that which a common house pet entails, provided one uses a little common sense and a little knowledge of natural history. This book provides information for those interested in keeping wild animals whether at home or in a zoo. Since their care is tied up with the habits of the particular species some space is devoted to the behavior of the animal in the wild. Types of food, cages, traps, and methods of handling for the most common mammals, reptiles, and amphibians are described. Since birds cannot legally be caged, methods of feeding and attracting them are mentioned. The author wisely stresses the fact that the owner should always strive to understand the animal's point of view for its reactions, even when the finger is severely bitten.



FURTHER EXPERIMENTS IN THE BREEDING OF OYSTERS (*OSTREA EDULIS*) IN TANKS. *Fisheries Investigations, Series II, Vol. XVI, No. 4.*

By H. A. Cole. *His Majesty's Stationery Office.* London. (Obtainable in America from the British Library of Information, 270 Madison Ave., New York). 28. net. $10\frac{1}{2} \times 7$; 51; 1939 (paper).

This publication describes the method employed and the success obtained by the author in his oyster-breeding experiments made during 1937 and 1938 in large concrete tanks at Conway, North Wales. From the data at hand, there appear to be enormous commercial possibilities in starting the spat on limed tiles in tanks. The larvae can be accelerated in growth and encouraged to settle earlier by controlling the organic food supply of the flagellate protozoa which make up the greater part of the diet of larval oysters.

The relation of temperature to the spawning among ripe females, and to growth of oyster larvae is not clearly understood, but it is thought that a sudden change in temperature, particularly a rise of several degrees, will stimulate both. The general conclusions herein reached point to the fact that the natural supply of oysters may be augmented by hatching and caring for the immature forms in experimental tanks.



THE MIGRATION AND CONSERVATION OF SALMON. *Publication of the American Association for the Advancement of Science No. 8.*

Edited by Forest R. Moulton. *The Science Press, Lancaster, Pa.* \$2.00. 10 $\frac{1}{4}$ x 7 $\frac{3}{8}$; 106; 1939.

This publication represents the contributions of some nine distinguished investigators in the field of migration and conservation of salmon. It is the first A.A.A.S. publication to be devoted to a purely biological subject.

It is evident that much is yet to be learned about the migration of salmon, but several interesting conclusions have been reached. The first is that the salmon of a given species may in a particular locality represent a more or less distinct entity, for which the term "stock" has been chosen. There are numerous differences between these local stocks, but it is not yet known whether or not these differences are heritable. A second discovery is that salmon return predominantly to the rivers of their origin. Finally, it has been found that proof of any general decrease in the stock of Atlantic salmon is lacking.

THE DISTRIBUTION OF INSECTS, SPIDERS, AND MITES IN THE AIR. *U. S. Department of Agriculture. Technical Bulletin No. 673.*

By P. A. Glick. *Government Printing Office, Washington.* 25 cents. 9 $\frac{1}{8}$ x 5 $\frac{1}{2}$; 150 + 5 plates; 1939 (paper).

Vertical exploration of the earth's surface is still in an embryonic state, but several attempts have been made to explore the regions beyond the confines of our two dimensional environment. This bulletin gives the results of insect trapping at high altitudes by airplane. Over 30,000 specimens of insects and their relatives were taken at altitudes ranging from 20 to 15,000 feet. It was found that size, weight, and buoyancy of the insect are involved in the determination of the height at which it was captured. Temperature, intensity of air currents, convection and turbulence were found, among others, to affect the number of insects caught and their dispersal. Collections were made during the day and night in every month of the year and the results of these collecting trips are fully tabulated. The technique employed is also explained and illustrated.



THE WORLD OF INSECTS.

By Carl D. Duncan and Gayle Pickwell. *McGraw-Hill Book Co., New York and London.* \$3.50. 9 x 6; ix + 409; 1939.

Insects are among the earth's most interesting creatures and the more that is learned concerning them, the more wonderful appears their adaptability and instincts, their anatomy and physiology, their usefulness and destructiveness, their numbers and kinds. The authors of this book succeed in portraying these characteristic features of insects without resorting to dry scientific terminology. Whenever entomological terms are used they are fully explained and consequently the book reads like a novel, is as interesting as a biography, and as informative as a text. Many illustrations aid in making this a most excellent addition to the general literature on insects.

PROTOZOOLOGY. *Enlarged and completely rewritten edition of Handbook of Protozoology.*

By Richard R. Kudo. Charles C Thomas, Springfield, Ill., and Baltimore. \$6.50. 8 $\frac{1}{2}$ x 5 $\frac{1}{2}$; xi + 689; 1939.

This work is advertised as a second edition, but in reality it is a new work. The text has been completely rewritten and expanded to half again its former size, the illustrations are enlarged in size and increased in number, and an improved taxonomy has been employed. Even the name has been changed.

The Mycetozoa, generally claimed by the botanists, are included; if this step is justified the nomenclature should have been modernized, for at least one generic term used in this group has been preoccupied in Mollusca for more than a century. The index covers 47 pages and is very exhaustive.



ZOOLOGICA. *Scientific Contributions of the New York Zoological Society. Volume XXIV, Part 2, Numbers 6-9.*

New York Zoological Society, Zoological Park, New York. \$2.25. 10 $\frac{1}{2}$ x 7; 200 + 11 plates; 1939 (paper).

By far the longest paper in this series is the first (No. 6) on Deep-sea fishes of the Bermuda Oceanographic Expeditions: Family Melanostomiidae (pp. 65-239, 77 text figures), by William Beebe and Joselyn Crane. The other papers are on The eye structure of the four-eyed blenny, *Dialommus fuscus* Gilbert; Studies on virus diseases of fish. III. Morphological and experimental observations on the lymphocystis disease of the pike perch, *Stizostedion vitreum*; and Studies on lymphocystis disease in the orange filefish, *Ceratacanthus schoepfii* (Walbaum), from Sandy Hook Bay, N. J.



THE CHISEL-TOOTH TRIBE.

By Wilfred S. Bronson. Illustrated by the Author. Harcourt, Brace and Co., New York. \$2.00. 8 $\frac{1}{2}$ x 6; [6] + 200 + 4 plates; 1939.

In this generously illustrated volume, the

author attempts to acquaint the young with the habits, appearance, and activities of the many different kinds of rodents. After an introductory chapter on the tribe in general, the author goes on to give the reader personal glimpses into the lives of tree squirrels, ground squirrels, prairie dogs, woodchucks and beavers. Two chapters are devoted to the remarkable feats of the rat and mouse, while the chinchilla, porcupine, and rabbit also have their place. The volume contains much of interest to the young naturalist. The illustrations, in color and black and white, are both attractive and amusing.



TURTLES OF THE UNITED STATES AND CANADA.

By Clifford H. Pope. Alfred A. Knopf, New York. \$3.75. 8 $\frac{1}{2}$ x 5 $\frac{1}{2}$; xviii + 343 + v; 1939.

A great amount of labor has gone into the writing of this book, which describes primarily the distribution, habitat, and habits of the 63 species of turtles living in North America and on its shores. Further data are given on anatomy, reproduction, offspring, and rate of growth. As an introductory chapter much information is presented on the lives of turtles in general. Intrinsically interesting as the material is, the writer, in a forced effort to make his book entertaining, frequently indulges in sad witticisms that smell a little. Pictures are abundant and the bibliography is extensive.



THE LITTORAL FAUNA OF GREAT BRITAIN. A Handbook for Collectors.

By N. B. Eales. With a Foreword by Stanley Kemp. The University Press, Cambridge; The Macmillan Co., New York. 8 $\frac{1}{2}$ x 5 $\frac{1}{2}$; xvi + 301 + 24 plates.; 1939.

This book gives keys to the more common species of creatures to be found in the waters of the British coast. Because the literature on the inhabitants of littoral areas is scattered the author has set out to make it possible for the collector to identify his specimens down to the genus and

in some cases to the species, in this handy manual. Drawings of the morphology of representative specimens of the larger groups help in comprehending the descriptive terms used in the keys. There is an appendix which gives hints on shore collecting, and instructions on preserving material.



INDEX-CATALOGUE OF MEDICAL AND VETERINARY ZOOLOGY. *Part 3. Authors: C to Czzygan.* U. S. Department of Agriculture.

By Albert Hassall, Mildred A. Doss, Marion M. Farr, Gertrude B. Carson and Dorothy Bero. Government Printing Office, Washington. 40 cents. $9\frac{1}{2}$ x $5\frac{1}{2}$; 613-961; 1939 (paper).

Hassall and his able assistants have now brought forth the third part (cf. Pts. 1, 2, Q. R. B., Vol. 13, p. 468) of this valuable reference work to medical and veterinary zoology. For those who have the first two numbers, we make the suggestion that there be no delay in obtaining the third since the catalogue is not intended for general distribution and the edition is limited. The price is so very low for each number that the total amount expended when the catalogue is completed will be comparatively small.



KONGO. *The Elephant.*

By E. Cadwallader Smith. Illustrated by Anne Vaughan. Alfred A. Knopf, New York. \$2.00. $9\frac{1}{2}$ x $6\frac{1}{2}$; [8] + 78; 1939.

Simply and pleasantly told is this story of Kongo—how he was born and grew up in the middle of an African jungle and finally became king of the herd. His adventures, battles and romance should be of more than fictional interest to the young reader as the author has used in his story only elephant facts which have been reliably checked for their accuracy. The illustrations, both in color and black and white, are unusually attractive.



LABORATORY DIRECTIONS IN GENERAL ZOOLOGY. *Third Edition, Revised.*

By Winterton C. Curtis and Mary J. Guthrie. John Wiley and Sons, New York; Chapman and Hall, London. \$1.50. 9 x $6\frac{1}{2}$; xxxiv + 195; 1939.

This edition (cf. Q. R. B., Vol. 9, No. 1 for second edition) has been thoroughly revised, the work in vertebrate embryology extended, a section on heredity and variation (in which experiments on *Drosophila* have been outlined) added and the number of figures increased. The changes have been made to accord with the third revision of the author's *Textbook of General Zoology*.



A CHECK LIST OF NORTH AMERICAN AMPHIBIANS AND REPTILES. *Fourth Edition.*

By Leonhard Stejneger and Thomas Barbour. Harvard University Press, Cambridge. $9\frac{1}{2}$ x 6; xvi + 207; 1939.

This useful check list last appeared in 1933 (cf. Q. R. B., Vol. 9, p. 113). The present edition follows the same plan of the earlier editions but it is larger than the third by about 20 pages. A good deal of new material has been added and some changes in classification have been made.



LIFE HISTORIES OF NORTH AMERICAN WOODPECKERS. *Order Piciformes.* Smithsonian Institution. U. S. National Museum Bulletin 174.

By Arthur C. Bent. Government Printing Office, Washington. 50 cents. $9\frac{1}{2}$ x $6\frac{1}{2}$; viii + 334; 1939 (paper).

This long and complete study of the North American woodpecker discusses in detail the habits and distribution of over 60 subspecies. Many excellent photographs, a long bibliography and a complete index are included.



BOTANY

BIO-DYNAMIC FARMING AND GARDENING. *Soil Fertility, Renewal and Preservation.*

By Eberhard Pfeiffer. Translated from the German by Fred Heckel. Anthroposophic Press, New York; Rudolf Steiner

Publishing Co., London. \$2.25. 8 x 5½; vii + 220; 1938.

Based on Goethe's concept of the "organic whole" of natural processes, Rudolf Steiner has worked out a system of agriculture which he believes is biologically correct, and therefore economically most profitable. Rotation of crops is involved, but the return to the soil of specially treated manure is the key-note of the system. Instructions for the handling of compost piles, and formulae for the reagents used in preparing manure for its return to the soil, will be furnished by the author upon proper request. A hint as to the nature of these preparations is contained in the following quotation:

control can be obtained by the use of certain plant preparations which induce the right kind of fermentation. This is done by the use of various plants which have always been employed also as medicinal herbs, such as: camomile, valerian, nettle, dandelion, horsetail, etc. These plants are themselves first put through a long fermentation process, buried at specific depths in the earth in close contact with certain parts of an animal organism. The process can be described by saying that through a kind of hormone influence the fermentation is guided in a definite direction [p. 45-46].

The initial quality of the manure is important; and this is dependent on proper stock feeding, which improves the health of the animals, and in last analysis contributes to the health of man. Crops grown on properly treated soil are of better quality, and in some cases, according to the author, they have had definitely beneficial effects in the treatment of digestive disorders.



CATTLE FODDER AND HUMAN NUTRITION.
With Special Reference to Biological Nitrogen Fixation.

By Artturi I. Virtanen. Cambridge University Press, London; Macmillan Company, New York. \$2.25. 8½ x 5½; 108; 1938.

Investigations on nitrogen fixation in plants has shown that leguminous crops not only transfer soluble organic-nitrogen compounds to the soil, thereby improving its quality and promoting the activity of soil microflora, but also accumulate remarkably large quantities of amino-acids and proteins in their own structure. Legumes are thus in a position to play a

decisive rôle in the production of milk, to make it economically profitable and biologically self-supporting. The method for effectively exploiting their value as a cattle feed is one of the most important contributions to animal nutrition in recent years. In four brief lectures, delivered in England in 1937 and now published in book form, the Finnish biochemist Virtanen describes how young and succulent legumes, rich in vitamins and in proteins generally, may be preserved over the winter with only slight nutritive losses. The winter feeding of cattle may thus be improved at reduced cost. With the suggested change in forage production winter milk comes to approach summer milk in its vitamin potency, so that the improvement in cattle feeding is also highly significant for human nutrition. Thus the normal dietary of a people may be made more adequate at the source, winter and summer alike, without the expense of supplementary foods. Evidence accumulates day by day that the Finns are a remarkable people.



THE ECONOMIC BOTANY OF THE KIOWA INDIANS.
As it Relates to the History of the Tribe.

By Paul A. Vestal and Richard E. Schultes. Foreword by Clyde Kluckhohn. Botanical Museum, Cambridge, Mass. \$2.00. 10¼ x 7¼; xiii + 110 + 4 plates; 1939 (paper).

The possibility of using the economic botany, both present and past, of a particular tribe or community of natives in studying their migration, their contact with other tribes, their industry, and in general, their success in the business of living, has been grossly neglected up to the present time. This has been true because of the fact that no one person has felt well enough trained in both botany and ethnology to undertake such an enterprise. The authors of the present volume have exhibited excellent team work, and their contribution to the field of ethnobotany will undoubtedly elicit the approval of both botanists and ethnologists.

Some 45 families of plants are listed, together with the different species by their

scientific names and the names which are, or have been at some time, used by the Kiowa Indians. The list includes everything from bear grass (*Andropogon saccharoides*), which is used for tooth-picks, to the horse mint (*Monarda fistulosa* L.), which is dried and powdered and used to rub over the head for headaches, over the body for treating fever, and as a remedy for sore eyes and colds. Chapter V lists these plants according to usage by the Kiowas.

A list of bibliographic references including 58 titles, a group of 4 plates of photographs of several important plants, and a complete index make up the remainder of the volume.



PLANT PHYSIOLOGY. *A Textbook for Colleges and Universities.*

By Bernard S. Meyer and Donald B. Anderson. D. Van Nostrand Co., New York.

\$4.50. 9 x 6; x + 696; 1939.

Written to aid students, and not, as is usually the case, to impress professors, this text is one of the best elaborated in recent years. The first 60 pages deal adequately, clearly, and simply with the physico-chemical phenomena to be used in the treatment of the subject matter. Continual reference is made to the phases in plant physiology to which the phenomena under discussion apply. The extensive use of many structural formulae and chemical equations will delight those readers chemically inclined. The utilization of many graphs and tables help greatly to make the explanations used completely understandable.

The bibliographies presented at the ends of the chapters, although selected, are extensive. The lists of questions appended to most of the chapters will both aid the student to summarize his reading and will, as put by the authors, act as "a catalysis of class discussion." The addition of a history of plant physiology, however, would have made for a more complete book and given the student a clearer concept of the gradual growth of the subject.

THE ANAEROBIC BACTERIA AND THEIR ACTIVITIES IN NATURE AND DISEASE. *A Subject Bibliography (In Two Volumes).* Volume I: *Chronological Author Index.* Volume II: *Subject Index.*

By Elizabeth McCoy and L. S. McClung. University of California Press, Berkeley. \$10.00 for the two volumes. 11 x 8½; Vol. I: xxiii + 295; Vol. II: xi + 602; 1939.

Here in two volumes is a bibliography that has many useful features. The Chronological Author Index lists alphabetically by senior author within each year all articles on anaerobic bacteria available to the compilers. Beginning with 7 theses in 1816, the number of titles per year has grown until, in September 1938, when the bibliography went to press, over 200 articles had appeared in 9 months. The Subject Index presents an organization of the literature on anaerobic bacteria which is interesting in its own right. The subject index outline, covering 6½ pages, has categories for all imaginable phases of bacteriological study. In each sub-section, references are again given alphabetically by senior author within each year. Titles of articles may be found by referring to volume I. Also included are several special indices to the bibliography itself, which are helpful in its use.



DATING PREHISTORIC RUINS BY TREE-RINGS. *General Series, Bulletin No. Eight.*

By W. S. Stallings, Jr. Laboratory of Anthropology, Santa Fe, New Mexico. 50 cents. 9½ x 6½; 20; 1939.

This is a brief essay on the discovery, development, methodology, and applications of dendrochronology (study of tree-rings). In 1901 Dr. Andrew Ellicott Douglass of the University of Arizona began the study of tree-rings in relation to climatic problems, but it was not until 1914 that the cross-dating or cross-identification of annual tree-ring patterns was applied to the study of archaeology. This method of dating archaeological ruins came about as a by-product of Douglass's interest in climatology. It has subse-

quently proved to be one of the most important contributions ever made to American archaeology. Through this work on tree-ring chronology actual dates for the ruins of the Basketmakers and the Pueblos of the Southwest have been established. The author has very simply and clearly explained the methodology and application of tree-ring study to archaeology. This brochure should serve as an excellent introduction to any further reading in a little-known field. A small but comprehensive bibliography is appended.



MAN AGAINST MICROBE.

By Joseph W. Bigger. Macmillan Co., New York. \$2.50. 7 $\frac{1}{2}$ x 5 $\frac{1}{8}$; 304; 1939. To the biologist this book may not seem very fundamental. But the author states that he is writing for the educated layman, and from this viewpoint it is an excellent introduction to microbiology.

After a brief essay on Antony van Leeuwenhoek and his work, the reader is told of the different kinds of microbes, methods of studying them, how man becomes infected, and how the body resists invasion. The second part is an interesting treatise on the history of microbiology from the earliest studies on spontaneous generation to relatively recent work in immunology and chemotherapy. Particular emphasis is placed on the contributions of Koch, Jenner, Pasteur, Metchnikoff, Ehrlich, Bordet, and d'Herelle.

According to modes of transmission of the causative agents, numerous diseases and their epidemiology are discussed. A good index and glossary help to make this a suitable volume for the general reader.



TREES OF THE SOUTH.

By Charlotte H. Green. University of North Carolina Press, Chapel Hill. \$2.50. 8 $\frac{1}{2}$ x 5 $\frac{1}{8}$; xiv + 551; 1939.

The purpose of writing this volume was, in the words of the author, "... to arouse an understanding, and an appreciation of trees, for their beauty, their wonder, and their use." Mrs. Green's love of nature,

and her intimacy with living things have given her volumes *Birds of the South* and *Trees of the South* lasting charm and genuine interest.

The present volume begins with a brief description of the parts of a tree and their functions; the flowers, fruits and seeds of a tree; and the uses of trees. There follows a detailed description and classification of some 27 families of familiar southern trees. Each species is described and photographed in its own setting. There are additional photographs of bark, leaf, bud, blossom, etc., that will aid in identifying and classifying each species. A table of contents and a useful index complete this excellent volume.



THE BIOLOGY OF BACTERIA. *An Introduction to General Microbiology. Second Edition.*

By Arthur T. Henrici. D. C. Heath and Co., Boston. \$3.60. 8 $\frac{1}{2}$ x 5 $\frac{1}{8}$; xiii + 494; 1939.

While this text deals in the main with bacteria, a considerable part of the work has to do with protozoa and fungi and other forms of microbic life. It was designed for the general or nontechnical student who would take but one course in microbiology, or as an introductory course for other students who would be taught particular applications of the science in advanced courses. In the second edition, some revision has been made in almost every chapter; the nomenclature and classification of bacteria have been changed to conform to the fifth edition of Bergey's *Manual*; two new chapters have been added dealing with the effect of environmental factors upon bacteria and with the distribution of bacteria in soil, water, milk, and the human body.



PFLANZENZÜCHTUNG. *Sammlung Göschen Band 1134.*

By Hermann Kuckuck. Walter de Gruyter und Co., Berlin. RM. 1.62. 6 x 4; 125; 1939.

The practical aspects of plant culture are stressed in this small volume. The illus-

trative examples presented for the demonstration of various methods are largely confined to vegetables and cereals. Two short chapters give the essentials of plant pathology and plant physiology which the horticulturist should know. A short selected bibliography, a glossary of the principal technical terms, and an index have been provided.



GROWING PLANTS WITHOUT SOIL. *The A. B. C. of Plant Chemiculture. (Soilless Agriculture, Chemiculture, Water Culture, Hydroponics, Tank Farming, Sand Culture). Including Plant Growth Hormones and Their Use.*

By D. R. Matlin. Chemical Publishing Co., New York. \$2.00. 8½ x 5½; [10] + 139; 1939.

This hand-book on plant chemiculture has grown out of a course given by the author to a class at the Belmont Evening High School in Los Angeles. It is well suited for high school work, or for the man in the street who has chosen this interesting phase of botany for his hobby.



MORPHOLOGY

BASIC METHODS FOR EXPERIMENTS ON EGGS OF MARINE ANIMALS.

By Ernest E. Just. P. Blakiston's Son and Co., Philadelphia. \$1.25. 9 x 6; x + 89; 1939.

The author sets forth basic methods for the handling of eggs and spermatozoa of marine invertebrates in experimental embryological investigations. The book, containing the author's notes on his laboratory methods, was written in direct response to the need evinced by embryologists for good, safe laboratory methods such as those used with success over a period of years by an experienced investigator. The author outlines general working conditions and precautions to be followed in the laboratory; the criteria for normal development of marine eggs; general considerations of methods for handling eggs and spermatozoa in the labo-

ratory and specific methods for handling those species which are most often used by experimental embryologists; some methods for preliminary experimental manipulations; and methods of fixation, clearing and imbedding, and staining. There is also an appendix in which the author gives the four classes into which eggs are divided according to the stage of maturation in which fertilization occurs in different species; the summary of means by which experimental parthenogenesis may be elicited in various eggs; and protocols on fixation and staining with iron haematoxylin and safranin. The book is bound in wire-o binding, a convenient form for laboratory use. An invaluable aid to experimental embryologists and cytologists.



FORM- UND STOFFWECHSEL DER GOLGI-KÖRPER.

Protoplasma-Monographien

Band 18.

By Gottwalt C. Hirsch. Gebrüder Borntraeger, Berlin. RM. 28. 8½ x 5½; xi + 394; 1939.

The problem the author has posed is: What rôle does the Golgi apparatus play through its changes of form and content in the restitution of specific products in the cells? In an attempt to at least clarify some points necessary for its solution, he reviews and synthesizes in this monograph the literature, to which he himself has contributed much. Most of the work discussed at length has been done since the appearance of Jacob's *Das Golgische Binnenapparat* (1927) and G. Hertwig's *Allgemeine mikroskopische Anatomie der lebenden Masse* (1929), which the reader is advised to study, if he has not already done so, before proceeding with the present survey.

A welcome feature is a table of terms used, with definitions or descriptions, the name of the person who coined them, and the date, placed at the beginning of the book. The bibliography runs to about 1900 titles, alphabetically arranged by authors. This is preceded by the literature (authors and dates) arranged by specific organs or tissues. The book is profusely illustrated and adequately indexed.

THE STORY OF A BABY.

By *Mavis Hall Ess.* *The Viking Press,*
New York. \$2.50. 12 x 9; 63; 1939.
The Story of a Baby is a very readable book designed for both parents' and children's instruction in the embryology of the fertilized egg, its various stages of development, the birth of the baby, hospital care and homecoming. It was written as a result of the interest evinced by children and adults at the exhibit of human embryos arranged by the Loyola University School of Medicine at A Century of Progress, Chicago, 1933-1934. The author has not only carefully studied the various stages of uterine development, but has also observed living newborn babies in maternity hospitals. Thus, in addition to the author's excellent serially arranged drawings and diagrams of pre-natal development, there are delightful sketches of newborn babies in every conceivable sort of mood.

**HUNDERT JAHRE ZELLFORSCHUNG. Proto-plasma-Monographien, Band 17.**

By *L. Aschoff, E. Küster, and W. J. Schmidt.* *Gebrüder Borntraeger, Berlin.*
 RM. 16. 8½ x 5½; x + 285; 1938.

This volume, dedicated to Eugen Korschelt in honor of his eightieth birthday, may also justly celebrate the one-hundredth anniversary of cytology. It traces the major milestones in the progress of this science since its impetus in the classic investigations published by Schleiden (1838) and Schwann (1839). Küster reviews the work on the plant cell, Schmidt that on the animal cell, and Aschoff's contribution—almost half of the volume—treats the foundations of Virchow's cellular pathology and its advances. The treatment is necessarily sketchy in parts, but nevertheless the book provides a good survey of the subject. Bibliographies for the separate parts would add to its usefulness. Author and subject indices have been provided.

**PRINCIPLES OF DEVELOPMENT. A Text in Experimental Embryology.**

By *Paul Weiss.* *Henry Holt and Co., New York.* \$5.00. 8½ x 5½; xix + 601; 1939.

This is an excellent comprehensive study of development for the advanced student of biological sciences. The text is divided into four sections: (1) the phenomena of development; (2) the methods of studying development; (3) the principles of development; and (4) the development of the nervous system. The 130 experiments described in the text are used to clarify textual discussions and may also be carried out in the laboratory by the student. There are numerous illustrations and an extensive alphabetically arranged bibliography.

The sub-title as given above is incomplete as the author also takes up the question of post-embryonic development and analytical methods other than experimental.

**SUPERFLUOUS HAIR and Its Removal.**

By *A. F. Niemoeller.* *Harvest House, New York.* \$2.00. 7½ x 4½; 155; 1939.
 In this treatise, the woman with superfluous hair is advised not to waste her time or money on so-called cures, but instead to apply herself to its safe and effective removal. This book describes in detail every method and device used in the removal of unwanted hair. Medical products, commercial preparations and home treatments are discussed at length and chapters are devoted to electrolysis, diathermy, and X-rays as well as to shaving, depilatories and other methods in more common use. In the final chapter the author gives the formulae for various home treatments and leaves the bewildered female to fend for herself.

**A TEXTBOOK OF ANATOMY AND PHYSIOLOGY. Sixth Edition, Revised.**

By *Jesse F. Williams.* *W. B. Saunders Co., Philadelphia and London.* \$2.75. 7½ x 5½; 607; 1939.
 The original plan of this excellent treatise remains unchanged. It presents, for the

student outside of medical schools (nursing, physical education, etc.), a sound integration of the knowledge of human structures and functions so that the essentials of anatomy and physiology can be studied as one subject. The revision has been in the direction of incorporating all recent advances in these fields: Chapters I, II, and III have been considerably reorganized. The summaries and questions at the end of each section and the excellent glossary and index and the illustrations, which number 367 (29 in color), help to make this a most useful guide for teacher and student.



ALLGEMEINE GEWEBELEHRE (*Histologie*).
Sammlung Götschen Band 1133.

By *Erich Ries*. *Walter de Gruyter und Co., Berlin*. RM. 1.62. 6½ x 4; 130; 1939.

This small volume of the Götschen series is suitable for student use. The historical treatment (Part I) is brief, emphasis being placed on the new methods discussed in Parts II (general) and IV (special, by type of organ or structure). Part III discusses in thirteen pages the structure and functional phenomena of cells and tissues. A glossary and an index have been provided. The bibliography is confined to a few German and French textbooks.



AN INTRODUCTION TO HUMAN ANATOMY.
Second Edition, Revised.

By *Clyde Marshall*. *W. B. Saunders Co., Philadelphia and London*. \$2.50. 8½ x 5½; 388; 1939.

This useful elementary text (cf. mention of first edition, Q.R.B., Vol. 11, p. 243) has been revised so that

it might better achieve its aim which is to supply in addition to the facts of anatomy, in the narrow sense, a brief account of the functional activities of the different organs and of related problems of practical interest. . . . A number of new figures have been added, and a great many more have been clarified and improved.

PHYSIOLOGY AND PATHOLOGY

NUTRITION AND PHYSICAL DEGENERATION.
A Comparison of Primitive and Modern Diets and Their Effects.

By *Weston A. Price*. Foreword by *Earnest A. Hooton*. *Paul B. Hoeber, Inc., Medical Book Department of Harper and Bros., New York and London*. \$5.00. 9¼ x 6; xviii + 431; 1939.

According to the author, primitive peoples not in close contact with the white man have well-developed mandibular and little evidence of dental decay, while those primitive peoples that have acquired some of the habits of the white man frequently develop facial malformations and carious teeth. The reason, Price opines, is that when left to himself primitive man adheres to the food habits which centuries of experience have shown to be most satisfactory for all physiological requirements, but when he becomes closely acquainted with the customs of the white man he learns about foods which do not contain all the necessary elements for health. This deduction is based on the premises that malnutrition (avitaminosis especially) attributable to or correlated with the mores of modern civilization is responsible for the prevalence of dental caries. To substantiate his conclusions the author reports some of his observations as well as those of others, comparing the dental state of isolated and modernized subgroups of such peoples as the Swiss, Gaels, Eskimos, North American Indians, African natives, Melanesians, Polynesians, Australian, Maori, and Peruvian Indians. More than by a statistical presentation of evidence the writer reinforces his arguments by the case method. He includes in this book many beautiful photographs of perfect denture in the primitives and of malformed jaws and extensively carious teeth in the modernized. The illustrations are so striking that they resemble the "before and after" treatment advertisements, a fact which together with a marked tendency to overstatement detracts from the strength of the arguments regarding the two main points of the book; viz., (a) the relation of diet to dental decay, and (b) the manifestations

of primitive wisdom in the selection of food. A short bibliography is appended to each chapter and there is a very laudatory preface by Prof. E. A. Hooton.



LA FRAGILITÉ OSSEUSE CONGÉNITALE (*Maladie de Durante*).

By H. Fulconis. *Masson et Cie, Paris*. 28 francs. 9 x 6; 134; 1939 (paper).

The problem of congenital bone fragility in man has long been a puzzle to the entire medical profession. It has been found that some case histories of the malady closely follow the Mendelian mechanism of inheritance, while others defy all the known laws of heredity. In some cases the bones have been found broken in the foetus, while in others fragility appears at varying time intervals anywhere from birth to 12 or 14 years of age.

In this excellently prepared treatise M. Fulconis has brought together all the available clinical material on the subject, and to supplement his fundamental conclusions has presented some carefully planned experimental data. From the evidence at hand, it appears that the malady is not connected with the processes of calcification or decalcification of bones, but rather, with faulty material (probably associated with the endocrine complex of the mother) which is built into the bones. The parathyroid and oestrogenic hormones seem to be the ones most concerned. In his experiments, the author fed young rats on the milk of castrated mothers, and they soon developed a condition quite similar to bone fragility in man. This was also the case when the young were fed the milk from partially thyroparathyroidectomized females. These experiments give a hint as to the causes which may be present in the case of the child after birth. The same may be true for the cases where the malady appears in the foetus, though the evidence is not yet clear enough to determine whether the cause lies within the mother, the foetus, or in both.

The text is supplemented by a generous supply of tables, charts and photographs.

An extensive bibliography, and an index complete the volume.



THE PHYSICAL STATES OF PROTOPLASM AT LOW TEMPERATURES. *Review and Critical Study*. *Biodynamica*, No. 48.

By J. Luyet and P. M. Gehebio. *Biodynamica*, Normandy, Missouri. 9½ x 6½; 138; 1939 (paper).

Luyet and Gehebio in this report make a direct hit against the old definition of a biologist, namely: "a biologist is a man with scientific aspirations but without the necessary mathematical background." They open with a very clear discussion of the four states of matter (gas, liquid, crystal, and glass). The next section of the report deals ably with the so-called, "problem of the wall" used in the study of heat conductivity through a solid. The following divisions deal with freezing and the frozen state, supercooling and the supercooled state, and finally the vitreous state. The authors also point out that the methods of measurement used by physicists in their most exact work are no "open sesame" for the biologist and often give results too coarse for the derivation of exact conclusions.

Many photographs, drawings, and graphs add to the clearness of the points and theories discussed in the text of the report. The effects of low temperature upon protoplasm are reviewed up to 1938. The bibliography is composed of 127 titles.



A COLLEGE COURSE IN HYGIENE.

By K. Frances Scott. *Illustrations by William D. Sargent, Margaret J. Sanders*. *Macmillan Co., New York*. \$2.50. 10 x 7½; 202 + xxx; 1939.

This course is divided into two main parts: (1) Hygiene as it concerns the individual; and (2) Hygiene as it concerns the group. The former section deals with the anatomy, physiology and psychology of the individual, and the latter with race, environment, communicable diseases, and present-day public health work. The

book is intended to be supplemented by lectures, discussions, and outside reading from the reference list which appears at the close of nearly every chapter. Stress is constantly placed upon the fact that the objective of a course of this type is the realization that health and health habits should not be a constant care or a conscious struggle, but rather, an unnoticed part of our daily routine.

One wonders why all the references are made to the female sex, when the volume is intended for a general college course. One wonders also what the reaction of a lively group of freshman lads would be to the section of the work-book which is devoted to a detailed record of menstruation. These peculiarities of the volume are clear when it is realized that the author is a teacher of physical-education in a girls' college and the book was written for use in her own classes. "Especially for Girls" should have been added to the title.



PHYSIOLOGY OF THE UTERUS *with Clinical Correlations.*

By Samuel R. M. Reynolds. Paul B. Hoeber, New York. \$7.50. 9½ x 6; xix + 447; 1939.

Physiologists are fortunate to have this book appear in print. Within its pages are assimilated the results of experimental research on the uterus carried out by hundreds of workers. These results are critically reviewed by the author who stands in a position in this field to select and criticize the material with competent judgment. We can do no better than to quote from the foreword:

In this book an important subject is given at last the attention it merits. To many readers the first reaction will be astonishment that so much is known about the physiology of the uterus, for there has been no previous general summary of all this work now laid before us by Doctor Reynolds.

Previously the labor involved in a search for these reports [literature of anatomy, physiology, pharmacology and medicine] has acted as a deterrent and has prevented the investigator and particularly the practitioner of gynecology and obstetrics from profiting adequately from the already numerous and illuminating facts on record.

There are many illustrations and a bibliography of over a thousand references. A work of prime importance.



PRIMITIVE TUBERCULOSIS.

By S. Lyle Cummins. John Bale Medical Publications, London. 10s. 6d. net. 8½ x 5½; viii + 213 + 3 plates; 1939.

This account of the incidence of tuberculosis in primitive peoples is concerned mostly with the African Negro and embodies the results of the author's extensive clinical experience as well as the observations of others. The author believes that the high mortality of the Negro from tuberculosis is explained by the lack of immunity.

The person who has no previous contact with tuberculosis is without the power to resist it. But the power to resist is gained, in ordinary civilized cases, very quickly, because the ancestors have been subjected, during innumerable years, to a process of weeding out. . . . The 'primitive' man, born without the power to resist, has not the advantage of ancestors such as this. . . . Given a quiet life and unlaborious days, . . . he may go on to elaborate a kind of immunity, liable to break down, however, if he chances to be in unfavorable conditions, but sufficient for his wants if he remains in his village.

The elaboration of this view constitutes the substance of this book in which the author discusses also theories on allergy and hypersensitivity. Although the author has made a noteworthy contribution in summarizing interesting material, his inferences for the time being are to some degree speculations.



CLINICAL DIAGNOSIS BY LABORATORY METHODS. *A Working Manual of Clinical Pathology. Ninth Edition, Thoroughly Revised.*

By James C. Todd and Arthur H. Sanford. W. B. Saunders Co., Philadelphia and London. \$6.00. 9 x 6; 841 + 12 plates; 1939.

Many changes have been made in this widely used text (cf. mention of the eighth edition in Q. R. B., Vol. 11, No. 1) in order "to make the book more valuable to students, teachers, physicians, and

laboratory workers." Only a few of them can be listed.

In the chapter on the blood, Vogel's old classification of anemias has been omitted, and a reclassification by Ottenberg substituted. Because of its simplicity, the old Westergren method for determination of sedimentation rate is now included. . . . Some of the obsolete procedures in urinalysis have been deleted. Included in the chapter on clinical chemistry is the complete technic of Bodansky for the determination of phosphate and phosphatase, with his tables for calculations; the complete technic of the sulfate method of Power and Wakefield also is included. To the tests for liver function has been added the hippuric acid test. Among the new tests should be mentioned the technic for the determination of serum lipase, the technic for the determination of cevitamic acid and sulfanilamide in blood and urine.



VERHÜTUNG ERBKRAKEN NACHWUCHSES.

Eine kritische Betrachtung und Würdigung.

Edited by St. Zurückzoglu. Benno Schwabe and Co., Basel. 17 Swiss francs. 10 x 7; 347; 1938 (paper).

Fifteen specialists have collaborated in the preparation of this book designed to outline and critically evaluate the eugenic and medical measures that have thus far been taken in Switzerland and other countries in an effort to prevent those who suffer from hereditary mental and physical afflictions from producing a second generation to which they might pass on these disabilities. The subjects of the chapters include general aspects of the problems; specific hereditary diseases, their mode of transmission and methods of control; methods of sterilization of the male and female; castration, and its effects on the sexual, social and mental attitudes of the patients after operation. With regard to the latter there still seems to be no consensus of opinion. The book concludes with a documentary record of the laws passed in various countries in regard to sterilization and castration. There is a subject index.



GUIDING PRINCIPLES FOR STUDIES ON THE NUTRITION OF POPULATIONS. *Series of League of Nations Publications III. Health 1939. III. 1. Technical Commission on Nutrition.*

By E. J. Bigwood. League of Nations, Geneva; Columbia University Press, New York. \$1.50. 9½ x 6; 281; 1939.

As is indicated by the title, this monograph outlines the techniques for investigating the food consumption and nutritional status of populations. In the first part the author discusses the methods of estimating the food consumption of nations, families, and individuals, with particular emphasis on household surveys. In the second part Bigwood describes in some detail the several anthropometric, physiological, and clinical procedures for studying the individual nutritional status. Data culled from various sources are used to illustrate the subject matter and in addition an appendix contains reproductions of records used in studies on nutrition. An adequate if limited bibliography is also included.



AN INTRODUCTION TO ANIMAL PHYSIOLOGY.

By W. B. Yapp. The Clarendon Press, Oxford; Oxford University Press, New York. \$3.00. 7½ x 4½; xv + 319 + 4 plates; 1939.

The writer of this book states that he is "treading on ground where no English angel has been before me" in attempting to cover in one elementary volume almost the whole range of animal physiology. He warns the student that the use of his book will require thought and common sense. We recommend it especially to those reviewing physiology and desiring a mass of data presented very economically. Many physiological experiments are dissected and the kernels presented for consumption. Illustrations are given where their presence will aid the text. The table of contents and the index are well planned and make for easy access to the body of material present. The list of reading suggestions at the end of the book seems all too brief.



BRUCELLOSIS IN MAN AND ANIMALS.

By I. Forest Huddleson. Contributing Authors A. V. Hardy, J. E. Debono and Ward Gilmer. The Commonwealth Fund,

New York; Oxford University Press, London. \$3.50. 9 x 6; xxi + 339 + 35 plates; 1939.

The present volume replaces Huddleson's *Brucella Infections in Animals and Man*, a treatise on methods of laboratory diagnosis. The material in the earlier volume has been revised and to it has been added a discussion of the general clinical aspects of the disease plus much general information concerning *Brucella* and brucellosis both in this country and abroad. Three outstanding authorities have collaborated with the senior author in the production of the book and their combined knowledge and experience has made it an important work for students and teachers of medicine, public health workers, laboratory clinicians, and veterinarians. According to Dr. Giltner, "Brucellosis is perhaps three times as prevalent as was tuberculosis at the time its eradication was begun." In man the mortality is low but the course of the disease is often marked by repeated relapses and it may become chronic. The volume contains a number of illustrations (some colored), graphs and tables, an appendix of case reports, a bibliography of 378 titles and an index.



OSMOTIC REGULATION IN AQUATIC ANIMALS.

By August Krogh. University Press, Cambridge; Macmillan Company, New York. \$4.00. 8½ x 5½; 242; 1939.

Krogh calls this review of what is known about the permeability of cells and tissues in water animals a "stocktaking." In any field where observations are plentiful and first principles few such a review is important, and in this field just now it is especially opportune. The scope of the book is somewhat wider than its title indicates. Data on the concentration and regulation of single ions have been included, for it is thought that the active transport of ions through cells into and out of the body fluids brings about osmotic regulation. The material is not arranged to bring out any physiological viewpoint, however; instead the observations are simply catalogued according to the major

systematic groupings of the animals on which they have been made. A special chapter is devoted to the osmotic conditions in eggs and embryos.



PNEUMONIA with Special Reference to *Pneumococcus Lobar Pneumonia*.

By Roderick Heffron. The Commonwealth Fund, New York; Humphrey Milford, London. \$4.50. 9½ x 6; xvii + 1086; 1939.

Third in the series of publications coming from the Massachusetts Pneumonia Study and Service, this book gives a comprehensive resumé of the present status of the disease, especially pneumococcus lobar pneumonia, in the laboratory and at the bedside. Though not attempting to be complete in any particular phase of the subject, the author brings into one volume material concerning the inciting agent, the lesions produced, and the clinical aspects of and the factors influencing treatment and recovery. The results of specific therapy in a large series of cases are included. The bibliography extends to over 1400 titles. The study is not only a picture of the current situation, but also a solid foundation for further advances.



LA RECHERCHE DE LA PATERNITÉ PAR LES GROUPE SANGUINS. Étude Technique et Juridique.

By Louis Christiaens. Masson et Cie, Paris. 26 francs. 7½ x 5½; 108; 1939 (paper).

The first half of this little book brings out the advances made in blood grouping since the initial discovery of Landsteiner. Special emphasis is placed on the inheritance of the blood groups and how the blood reactions of the offspring are related to that of the parents. The practical value of these physiological and immunological discoveries are discussed in the second half wherein the author demonstrates the importance of these facts in the medico-legal field. Progress in the utilization of blood groups as evidence of non-paternity, or maternity, in the law courts of various countries shows that the law has been

rather slow in some. The social implications of these physiological facts are discussed, one country claiming that they are becoming a "prophylactic method against immorality".



MATERNAL CARE AND SOME COMPLICATIONS
The Principles of Antepartum, Intrapartum, and Postpartum Care and of the Management of Some Serious Complications.

Edited by F. L. Adair. University of Chicago Press, Chicago. \$1.50. 7 $\frac{1}{2}$ x 5 $\frac{1}{4}$; viii + 194; 1939.

This volume, issued with the backing of the American Committee on Maternal Welfare, Inc., is a handy volume for general practitioners, internes, nurses and students. It combines the two handbooks *Maternal Care* and *Maternal Care Complications*. Except for minor changes the textual material is unchanged. The first section is divided into three chapters: Antepartum, Intrapartum, and Postpartum. The second part is also in three chapters: Emesis and toxemias of pregnancy, Obstetric hemorrhages, Puerperal infections. Both sections are clearly and simply written, with a minimum of technical words. Great emphasis is put on the importance of asepsis. A valuable guide.



DIE PHYSIOLOGIE DES WACHSTUMS UND DER BEWEGUNGEN.

By E. Bünning. Verlag von Julius Springer, Berlin. RM. 18 (paper); RM. 19.80 (cloth). 10 $\frac{1}{4}$ x 6 $\frac{1}{4}$; vi + 267; 1939.

This second volume of the *Lehrbuch der Pflanzenphysiologie*, edited by E. Bünning, K. Mothes and F. von Wettstein, divides into three parts: physiology of activity change and growth of plants, physiology of their mechanisms of movement, and physiology of irritating effects. Each chapter is provided with a bibliography and there is an index.

The first volume of the series, by Mothes, treated the physiology of plant metabolism. The third, and final volume of the set, in which v. Wettstein will treat the development of plants, is scheduled to appear soon, the war gods willing.

The complete work will be a useful addition to the plant physiologist's and biologist's library.



OUTLINE OF PHYSIOLOGY.

By William R. Amberson and Dietrich C. Smith. Illustrations by Norris Jones. F. S. Crofts and Co., New York. \$4.00. 10 x 6 $\frac{1}{2}$; vii + 412; 1939.

The teacher will find this an excellent introduction to the study of physiology for the beginning college student. The authors have succeeded in presenting simple but sufficiently comprehensive discussions of the important phases of the subject while formal and technical discussions of complicated points have been avoided. Brief introductory material on modern physical and chemical concepts are included. The 177 figures, many of them original, form an important part of the book. A detailed index is included.



THE GENUINE WORKS OF HIPPOCRATES.

Translated from the Greek by Francis Adams. With an Introduction by Emerson C. Kelly. Williams & Wilkins Co., Baltimore. \$3.00. 10 x 6 $\frac{1}{4}$; viii + 384; 1939.

This is by far the best printing that has ever been issued of Francis Adams' scholarly translation in the 19th century of the writings of Hippocrates. Most of the foot-notes with which Adams' translation was so extensively supplied have been deleted so that a more continuous and connected picture of medicine in the Golden Age of Greece might be presented. There is an introduction by Dr. Emerson Crosby Kelly on the little-known life of Hippocrates, the gathering together of his writings, and the authenticity of the works recorded in this book. At the end of the text there are two added sections—illustrations of medical instruments and identifications of them.



HUMAN PHYSIOLOGY. *A Textbook for High Schools and Colleges. Eighth Edition, Revised.*

By Percy G. Stiles. Revised by Gordon C. Ring. W. B. Saunders Co., Philadelphia and London. \$2.25. 8 $\frac{1}{4}$ x 5 $\frac{1}{4}$; 450; 1939.

To Professor Ring (long an associate of the late Dr. Stiles) fell the task of revising this well-known elementary text (cf. 7th edition, Q. R. B., Vol. 12, p. 120). The manner of presentation of the material remains largely as in previous editions since in many of the chapters only minor changes were required. Whenever it has been necessary to include new data, especially in the complex field of hormones and of vitamins, the discussion is in keeping with the elementary character of the book.



A PULSATING CIRCULATION APPARATUS FOR TISSUE CULTURES, EMBRYOS, AND SMALL ORGANS. *University of California Publications in Zoology, Volume 43, Number 10.*

By J. A. Long. *University of California Press, Berkeley.* 35 cents. 10 $\frac{1}{8}$ x 6 $\frac{3}{8}$; 5 + 1 plate; 1939 (paper).

This two-page paper describes a cleverly devised gadget for producing a pulsating current in the nutritive fluid of tissue cultures, embryos, and small organs being studied under the microscope. The apparatus consists of a series of wells and channels, through which the fluid is made to circulate in a pulsating rhythm by the tapping of a magnetic pendulum on a small rubber tube connected with the channels. The apparatus shows considerable original thinking, ingenuity, and mechanical skill.



LA MÉDECINE EXPÉRIMENTALE. *Organe de l'Institut de médecine expérimentale de l'Ukraine. Numbers 1 and 2, 1938 and Numbers 1 and 2, 1939.*

Edited by A. A. Bogomoletz, S. J. Steinberg and M. M. Langer. *Ukrainian Society for Cultural Relations with Foreign Countries, Kiev.* Nos. 1 and 2, 1938, 3 krb. 50 kop. each; Nos. 1 and 2, 1939, 5 krb. each. 9 $\frac{1}{4}$ x 6 $\frac{3}{8}$; No. 1, 1938, 114; No. 2, 1938, 113; No. 1, 1939, 76; No. 2, 1939, 95; (paper).

This new periodical is devoted to the publication of research in experimental medicine (including, of course, also clinical medicine, biology, bacteriology, physics, chemistry and other fields which are necessary adjuncts) in the Ukraine. In addition to the original articles each number lists the contents of foreign journals received by the editors. The more important papers and publications are reviewed.



HEALTH FOR 7,500,000 PEOPLE. *Annual Report of the Department of Health, City of New York for 1937 and a Review of Developments from 1934 to 1938.*

By John L. Rice. *Department of Health, City of New York.* 9 x 6; 390; 1939.

In this volume is given an elaborate account of the machinery of the Department of Health of New York City. The greater portion of the book is dedicated to a description of the function, budget, and personnel of each section and service. In an appendix are listed the publications of the members of the staff during the year 1937. Included in the present report are also the statistics of births and deaths of the year 1937.



LE MÉTABOLISME DE L'AZOTE. *La Physiologie des Substances Protéiques. II. Dégradation, Synthèse, Métabolisme intermédiaire. Fascicule 1. Le Catabolisme Protéique. Caractères, conditions, mécanismes généraux, agents exécutants et régulateurs. Les Problèmes Biologiques XXIII.*

By Émile F. Terroine. *Presses Universitaires de France, Paris.* 40 francs. 10 $\frac{1}{4}$ x 6 $\frac{3}{8}$; xii + [8] + 164; 1939 (paper).

This is one of a series of authoritative summaries of the present state of knowledge on the metabolism of nitrogen. The present number deals with the physiology and chemistry of protein catabolism. The bibliography contains 614 titles.



BIOCHEMISTRY

ANNUAL REVIEW OF BIOCHEMISTRY. *Volume VIII.*

Edited by James M. Luck and James H. C. Smith. Annual Reviews, Inc., Stanford University P. O., Cal. \$5.00. 8½ x 6; ix + 676; 1939.

The editors state in the preface that it is hoped "it will be possible to recognize the deep penetration of biochemistry into physiology by transferring [in the future] to the *Annual Review of Physiology* (cf. mention of Vol. 1, in Q. R. B., Vol. 14, No. 4) much subject matter which, hitherto, the reviewers have felt obliged to include in the *Annual Review of Biochemistry*." Both of these reviews are essential for a well-equipped biological library.

Because of the difficulty of adequately reviewing the greater number of published works in this rapidly expanding discipline, the editors of the present *Review* "have felt driven to the alternative solution—the publication of reviews in which, in the judgment of the authors, the contributions of major significance are critically appraised." The subjects as well as the reviewers (always outstanding authorities) usually change from year to year. Twenty-five subjects are discussed in this volume. It is only possible to mention a few of these, selected at random. K. Linderström-Lang writes on proteolytic enzymes; A. Tiselius on the chemistry of proteins and amino acids; R. W. Jackson and J. P. Chandler on metabolism of proteins and amino acids; E. M. Nelson and C. D. Tolle on fat-soluble vitamins; and C. H. Kellaway on animal poisons. As in previous issues each section is well documented and the volume concludes with useful author and subject indexes.



COMPOSITION AND PROPERTIES OF GOAT'S MILK AS COMPARED WITH COW'S MILK.
United States Department of Agriculture. Technical Bulletin No. 671.

By J. A. Gamble, N. R. Ellis, and A. K. Besley. U. S. Department of Agriculture, Washington, D. C. 10 cents. 9½ x 5½; 72; 1939 (paper).

This bulletin presents the findings of a group of government investigators concerning the comparative chemical, physi-

cal and food properties of goat's and cow's milk. Chemically, the goat's milk was similar to that of Holstein milk in percentage of water, protein, fat, and lactose. The goat's milk was found to have much smaller fat globules than either Holstein or Jersey milk, and a lower curd tension than the cow's milk. The essential differences in vitamin potency between goat's milk and cow's milk were that the former had a slightly higher vitamin B and G potency, and a lower vitamin E potency than the latter.

The report is highly technical, and in consequence, will not be of particular value for the farmer. However, it is a significant contribution to the general field of food analysis, and opens the way for numerous further studies of this type.



THE POISON TRAIL.

By William F. Boos. Hale, Cushman and Flint, Boston and New York. \$3.00. 8½ x 5½; 380; 1939.

Dr. Boos' life-time experience in toxicology has given him a variety of experiences of which he writes with interest and enthusiasm. He tells of his work as a physician in this field, and of his experience as a consultant in the use of poison for industrial purposes and in foods. Of most interest, however, is his work in the field of legal toxicology. In this volume he describes a number of the famous civil and criminal cases of the last twenty years in which he has been an expert witness. The author's case histories and anecdotes of the use and misuse of various poisons make excellent reading. An appendix consisting of three formal reports on toxicological investigations has been included and there is a complete index.



HANDBUCH DER BIOLOGISCHEN ARBEITSMETHODEN. Inhaltsübersicht.

Edited by Emil Abderhalden. Urban und Schwarzenberg, Berlin. 9½ x 6½; 127; 1939 (paper).

This final number, constituting a detailed table of contents, marks the completion

of a monumental piece of editing and publishing. Our warmest congratulations go to editor and publisher. To say that the Abderhalden Handbuch is useful, is understatement. It is indispensable for any broadly organized biological laboratory. While in matters of detail it will, of course, get out of date—indeed in some sections already has—nevertheless it will long remain an invaluable reference work as a whole. It is interesting to note that each single part may be purchased separately. The price of the whole work, in 107 volumes bound in half leather, is RM. 4000.



KURZE GESCHICHTE DER KATALYSE IN PRAXIS UND THEORIE.

By Alwin Mittasch. Verlag von Julius Springer, Berlin. RM. 6.60. 8½ x 5½; viii + 139; 1939 (paper).

Very little was known about catalysis until about a century ago. In the first few pages of this book a resumé is given of some catalytic reactions observed up to the year 1800. The next decade saw the rise of more definite ideas on the subject, embodied in the works of Döbereiners, Bellani, Faraday, and especially Berzellius.

The chemical theory of catalysis was built up in the middle of the nineteenth century by Horstmann, who experimented in both inorganic and organic chemistry. Later students strengthened its position and added to the knowledge of biocatalysis. The work of Wilhelm Oswald is discussed at length, and later-day studies are briefly presented. There is an extensive index of authors.



ESSENTIALS OF PHYSIOLOGICAL CHEMISTRY. Second Edition.

By Arthur K. Anderson. John Wiley and Sons, New York. \$2.75. 9 x 5½; ix + 323; 1939.

In this edition the subject matter has been brought up to date. Many sections have been completely rewritten and new material added. More space has been

given to those sections dealing with enzymes (oxidations and reductions), intestinal putrefaction and detoxication, and respiration. The section on carbohydrate metabolism has been completely revised and the chapters on hormones and vitamins largely rewritten. A new chapter on Composition of tissues, covering the important facts concerning the composition of muscle, nervous, epithelial and connective tissue, has been added.



TRAITÉ DE CHIMIE ORGANIQUE. Tome X. Diacides et Polyacides. Matières Grasses. Dérivés Sulfurés ou Sélénités de la Fonction Acide.

By H. J. Goudet, R. Padova, F. Salmon-Legagneur. Published under the Direction of Victor Grignard, G. Dupont, R. Locquin and Paul Baud. Masson et Cie, Paris. \$6.45 (paper); \$7.10 (cloth). 9½ x 6½; xix + 807; 1939.

This is the eighth part of a 15 volume treatise to appear on organic chemistry. Preceding parts have been noticed in these columns, and like the other volumes, this one maintains the high standard set up by the first seven.



SEX

SEXUAL FREEDOM.

By René Guyon. Translated from the French by Eden and Cedar Paul with an Introduction by Norman Haire. John Lane the Bodley Head, Ltd., London. 15s. net. 8½ x 5½; xiv + 344; 1939.

One cannot help but admire the untiring zeal with which advocates of sexual freedom go about their work. There is no doubt that the subject of sex is spoken of with greater freedom than it formerly was, and even that certain taboos are disappearing. However, it is doubtful if any part of the gradual change is due to this book and numerous others almost identical in subject matter.

The volume contains a lot of tiresome reading under the general topics of the need for sexual freedom, its guiding principles, its message, its practice, sex

relations, and "psycho-physiology of the erotic life."

"... it is easy to understand that, in both sexes, the pursuit of a partner for amorous dalliance has all the excitement of the chase, being no less full of surprises, disappointments, and triumphs. That, of course, explains its unfailing charm. It is certainly the most captivating of sports."

All those who wish to become members of the Hunt Club kindly turn to page 136 and subscribe to the twelve exalted by-laws.



HOW TO ACHIEVE SEX HAPPINESS IN MARRIAGE.

By Henry and Freda Thornton. *Vanguard Press*, New York. \$2.00. 7½ x 5; xii + 155; 1939.

Both to the happily married who wish to avoid "the perils of monotony", and to the unhappily married (sexually), this book offers advice. Variations and new techniques are described for the former, while the latter are given suggestions to awaken their sexual lethargy or to remove any barriers that have arisen which tend to mar their marital pleasures. A new feature that crops up in this far from unique type of book is a discussion of vocabulary and of proper terms to use. [Reginald, the Office Boy, claims, however, that they missed several good ones.] Another feature is that the book is perfectly frank and to the point and should satisfy those who desire their information "straight from the shoulder". Unimaginative married couples are probably the ones who will derive the most benefit.



THE RHYTHM OF STERILITY AND FERTILITY IN WOMEN. *A Discussion of the Physiological, Practical, and Ethical Aspects of the Discoveries of Dr. K. Ogino (Japan) and Prof. H. Knaus (Germany) Regarding the Periods when Conception is Impossible and when Possible. Sixth Revised Edition.*

By Leo. J. Latz. *Latz Foundation*, Chicago. \$1.00. 6 x 4; vii + 151 + 5 folding charts; 1939.

This little book (published with the approbation of the Church) is now in its sixth revised edition (cf. notice of first edition in Q. R. B., Vol. 8, p. 237) and eleventh printing. It is in three parts: (1) physical aspects, (2) practical aspects, and (3) ethical aspects. The question-answer method, so effective with those who find difficulty in organizing their own thoughts, has been maintained.



THE VAGINAL DIAPHRAGM: *Its Fitting and Use in Contraceptive Technique.*

By Le Mon Clark. *C. V. Mosby Co.*, St. Louis. \$2.00. 8½ x 5½; 107; 1939.

Physicians will appreciate this book for the valuable information it imparts concerning the vaginal diaphragm as a method of contraception. The author does not enter into the social or economic aspects of birth control but sticks to the subject as indicated by the title. Physiological and anatomical considerations, methods of examination and fitting, together with a description of the diaphragm itself and of vaginal jellies and creams, are all part of the subject matter. Physicians are told how to instruct the patient to make sure she learns the correct procedures. Over fifty illustrations and photographs complete this comprehensive manual.



FEMININE HYGIENE IN MARRIAGE.

By A. F. Niemoeller. *Harvest House*, New York. \$2.00. 7½ x 4½; 155; 1938.

In this small volume, the author discusses the use and abuse of various medicaments and apparatus in a language simple enough to be interesting and of use to the average woman. Beginning with a description of the female sex organs and the mechanism of menstruation, the author goes on to discuss various female disorders and diseases and their treatment. A chapter on douches, hygiene in pregnancy, and on the menopause have been included. Throughout the author warns against the use of quack patent medicines for feminine ailments.

BIOMETRY

QUANTITATIVE ZOOLOGY. *Numerical Concepts and Methods in the Study of Recent and Fossil Animals. First Edition.*

By George G. Simpson and Anne Roe.
McGraw-Hill Book Co., New York and London. \$4.00. 9 x 6; xvii + 414; 1939.

This contribution to the methodological literature of biology at once takes a place of the first rank in usefulness and importance. The title would seem to restrict it to the field of zoology, but no biologist should allow himself to be misled by this expression of the modesty of the authors. Botanists, and biologists generally, will find it just as useful and helpful as zoologists, even if the illustrations of methods are drawn chiefly from the data of zoology and paleontology.

The coverage of the elements of modern biometric techniques is ample to meet the needs of any biological worker, and probably will continue to be for a good many years to come. This is evident from the chapter heads: Types and properties of numerical data; Mensuration; Frequency distributions and grouping; Patterns of frequency distributions; Measures of central tendency; Measures of dispersion and variability; The normal curve; Probability and reliability; Sampling; Comparisons of samples; Small samples and single specimens; Correlation; Regression; Association; Graphic methods; Growth.

An Appendix gives practical hints on computation; assembled symbols and formulas used; and a glossary. A selected bibliography and index complete the volume.

The derivations and explanations of the mathematical methods used are painstakingly detailed, and should be crystal clear to anyone, especially as the writing throughout has the charming lucidity that characterizes the senior author's other works.

The book is remarkably, though not completely, free from slips. One should perhaps be mentioned here because it happens to be of just the type likely to mislead the class of persons for whom the

book is primarily intended. On p. 14 (footnote) it is stated that:

The mean of a ratio is most easily calculated by dividing the mean of one set of measurements by the mean of the other, but note that this is not proper unless all the measurements are paired. That is, if, for instance, a mean length:width ratio is sought, it may be obtained by dividing the mean length by the mean width if each length is accompanied by the corresponding width of the same specimen and each width by the corresponding length. This is not always true of paleontological data; and if unpaired measurements have been included in the means of the two primary measurements, the ratio of each individual must be taken and the mean of the ratios then calculated. The difference is seldom significant, but this procedure is technically the correct one.

This clearly implies, if the pairing condition is assumed to have been met, that

The Mean of a Ratio = The Ratio of the Means (of the variables entering the ratio) which is not true. Consider for example the following series of ratios:

$$\begin{array}{ll} 10/2 = 5.000000 & 14/6 = 2.333333 \\ 11/3 = 3.666667 & 15/7 = 2.142857 \\ 12/4 = 3.000000 & 16/8 = 2.000000 \\ 13/5 = 2.600000 \end{array}$$

The ratio of the means is $13/5 = 2.6$, but the mean of the ratios is 2.963265. The difference (0.363265) is not small; it amounts to 13.1 percent of the average of the two quantities entering the difference.

But such minor inadvertences will be cleared up in later editions, that are sure to be rather quickly demanded. For this is a first rate book, that we can recommend highly.



THE CONCEPTS OF THE CALCULUS. *A Critical and Historical Discussion of the Derivative and the Integral.*

By Carl B. Boyer. Columbia University Press, New York. \$3.75. 9 x 6; vii + 346; 1939.

It may seem strange to some readers to hear a mathematical treatise referred to as delightful reading, yet that is exactly what this work is. Not that it is simple reading—far from it. It is delightful reading because it is the history of an idea.

The calculus has sometimes been con-

sidered the supreme achievement of the human mind. It has also been said to have been the invention of Newton and Leibniz, but discovery would be a better word. But this is a very loose statement, for while the setting of the keystone may safely be attributed to these two titanic intellects, the cornerstone of the structure had already been laid in the time of Thales of Miletus, more than twenty centuries previously, by the Egyptians and Babylonians. In these pages we meet not only the great mathematicians of antiquity such as Pythagorus, Euclid, Eudoxus, and Archimedes, but also the more catholic philosophers, Plato, Aristotle, Democritus, and Zeno (who must have been great as a humorist as well as a metaphysician), Lucretius, and Plotinus.

The average man thinks of the Dark Ages as a period in which the advance of intelligence became a retreat. In reality they appear dark because our records are incomplete. They were an age of tradition, but they produced such thinkers as Leonardo of Pisa, Nicholas of Cusa, Richard Suiseth, Thomas Bradwardine, Nicole Oresme, Blasius of Parma, William of Occam, and Duns Scotus, to mention a few at random—all of them, men whose names can be mentioned with honor and dignity in any connection. Then came the renaissance of learning with such names as Stevin, Kepler, Galileo, Cavalieri, Torricelli, Descartes, Fermat, and Pascal, the last two of whom just missed making the discoveries that crowned the careers of Newton and Leibniz, who are the first of the strictly modern period, which produced also such men as Gauss, Euler, and Helmholtz. In the pages of this book we meet all these men and many others like them, and learn how they influenced subsequent thought.

The book's documentation is tremendous—several footnotes on nearly every page. There is a bibliography of 25 pages and a finely printed index of 10, but the book suffers by lack of a table of chronology. In a work that approaches its subject from the view point of history a chronological table is almost indispensable and it is unfortunate indeed that one was not compiled in the present instance.

PROBABILITY, STATISTICS AND TRUTH.

By Richard von Mises. Translated by J. Neyman, D. Skoll and E. Rabinowitsch. The Macmillan Co., New York. \$3.75. 8½ x 5½; xvi + 323; 1939.

Between the concept of probability as defined by the mathematician and a *posteriori* probability of the empiricist there exists a logical gap which troubles the mathematical philosopher. In the opinion of many mathematicians probability has yet to be defined in a manner that has practical significance and can serve at the same time as the starting point for the development of systematic rationalization. For this reason a number of definitions have been advanced and among the recent ones is that which Mises introduced almost two decades ago and discusses at length in this book. Mises defines probability as "the limiting value of the empirically observable relative frequency" and on this basis outlines very briefly the fundamental operations and applications of the theory of probability. The major portion of the book is, however, devoted to a defense of his views against the criticism received and a critical examination of the concepts of other mathematicians. Notwithstanding the theoretical nature of the subject and the metaphysical title, the author elucidates the problem and its practical statistical aspects in a better fashion than has usually been done. Particularly interesting are the interpretations of the theorems of Bernoulli and of Bayes in the light of his concepts.



ELEMENTS OF STATISTICAL REASONING.

By Alan E. Treloar. John Wiley and Sons, New York; Chapman and Hall, London. \$3.25. 9 x 5½; xi + 261; 1939.

Teachers of elementary statistics have come more and more to realize the need of explicitly indicating the logic of statistical procedures as well as the computational technique and theory of the formulae in use. The wisdom of this viewpoint is clearly demonstrated in Treloar's textbook in which, true to the title given it, the author plainly discusses the why and

wherefore of each procedure described. This is the distinctive feature of the present book which in order of exposition does not differ substantially from other elementary texts already available. After a short introduction, the author takes up centering constants, measures of variation and the normal curve. Several well-written chapters on correlation and regression follow. The theory of probability is next briefly discussed and the book closes with chapters on the chi-square test. In an appendix are contained many useful tables that add to the high quality of this as a textbook.



STATISTICAL DICTIONARY of Terms and Symbols.

By Albert K. Kurtz and Harold A. Edgerton. John Wiley and Sons, New York; Chapman and Hall, London. \$2.00. 7 x 4 $\frac{1}{4}$; xiii + 191; 1939.

An extremely useful reference book. It gives clear and accurate definitions of about 2,100 statistical terms. Alternative definitions are employed for those terms most frequently encountered in the literature, or where the meaning is difficult to comprehend; also examples are often used for elucidation. During the preparation of the book the authors issued a preliminary edition in mimeographed form which they submitted to an advisory council—a group of statisticians representing "six of the branches of science in which statistical methods find their greatest usefulness"—for criticisms and suggestions.



PRINCIPLES OF THE MATHEMATICAL THEORY OF CORRELATION.

By A. A. Tschuprow. Translated by M. Kantorowitsch. William Hodge and Co., London. 12s. 6d. net. 8 $\frac{1}{2}$ x 5 $\frac{1}{2}$; x + 194; 1939.

Most students of statistics are familiar with the German edition of Tschuprow's monograph and therefore will appreciate this good English translation of the work. For the statistical neophyte this represents an excellent opportunity to acquire a real

understanding of the logical principles that underly the several measures of correlation, especially as developed by Pearson. Tschuprow's treatment of the subject is distinguished by a simplicity of exposition which emphasizes particularly the difference between stochastic association and functional relationship, and avoids complex mathematics.



METHODS OF STATISTICAL ANALYSIS.

By C. H. Goulden. John Wiley and Sons, New York; Chapman and Hall, London. \$3.50. 9 x 5 $\frac{1}{2}$; vii + 277; 1939.

Some elementary training in statistical theory is presupposed in this textbook. Its emphasis, therefore, is on (a) the design of experiments, following R. A. Fisher's principles, and (b) routine training to familiarize advanced students with practical methods and to give them facility in calculation. The examples and exercises are chosen to be representative of the problems encountered in agricultural research.



WAHRSCHEINLICHKEITSRECHNUNG FÜR NICHTMATHEMATIKER.

By Karl Dörge in collaboration with Hans Klein. Walter de Gruyter and Co., Berlin. RM. 6. 9 x 6 $\frac{1}{4}$; 113; 1939.

Written to give non-mathematicians an understanding of the underlying principles of the theory of probability, this work loses much in clarity because of the brief treatment given many phases of the subject. Topics discussed include the concept of limits; the concept of probability; series of events; mathematical expectation; means and variation; and the laws of large numbers. The index is too brief and there is no bibliography.



MATHEMATICS FOR ACTUARIAL STUDENTS. Part I. Elementary Differential and Integral Calculus.

By Harry Freeman. The University Press, Cambridge; The Macmillan Co., New York. \$2.75. 8 $\frac{1}{2}$ x 5 $\frac{1}{2}$ inches; vii + 183; 1939.

This standard English textbook on actuarial mathematics has now been divided into two volumes of which the present is the first. With only minor changes this volume reproduces the chapters on trigonometry and elementary calculus that formed part of the previous edition. Succinct but adequate, the exposition is clear and accompanied by well-chosen examples.



PSYCHOLOGY AND BEHAVIOR

MOSES AND MONOTHEISM.

By Sigmund Freud. Translated from the German by Katherine Jones. Alfred A. Knopf, New York. \$3.00. 8 $\frac{1}{2}$ x 5 $\frac{1}{2}$; [6] + 218 + vi; 1939.

This is the last book written by Dr. Freud, and the only one during the last six years of his life. It would never have seen the light of publication had the author continued to reside in the city which had been his home for seventy-eight years, but the civilized world can now profit by the sad turn of affairs that compelled him to take up his residence in London only a short time before his death.

The commonly held belief that in this work Freud seeks to prove that Moses was an Egyptian is not strictly borne out by an examination of the work. The birth of the "austere man" of the Pentateuch remains as much of a mystery as his death. What the author attempts to prove is that Moses was a synthetic personality and that one of his component elements may have been an Egyptian. Freud's thesis is that Moses was an Egyptian of high social standing, probably a close friend of Ikhnaton, and a convert to his monotheistic theology; and that when after the death of Ikhnaton the priesthood chiseled his name off the monuments in order to obliterate all memory of him as the first step in the restoration of the polytheistic hierarchy, Moses found it expedient to flee to a border state where he could impose his monotheistic views on the slaves, whom he intended to lead into the desert to establish a monotheistic state. The tribe of Levi, Freud contends, owe their anomalous position in the Israelite political structure to the fact

that instead of being the descendants of Levi, son of Jacob, they were in reality the retinue of Moses who had fled from Egypt with him.

The monotheism of Ikhnaton proved too pure for the Israelites to assimilate, and it quickly degenerated into the worship of a tribal deity—the rival of Ashteroth, Baal, Chemosh, and Dagon. The Israelites were forbidden to worship these exotic deities (though they frequently did it) but were not forbidden to believe in them. Freud believes that Moses was murdered by his own followers, and his place taken by a Midianite imposter who assumed the name of Moses.

Psychoanalysis figures widely in the book and the story of the ark in the bull-rushes is rejected on psycho-analytic grounds. The ark is symbolic of the uterus, and the Nile of the amniotic liquid. This is an excellent illustration of the weakness of psycho-analysis—it often proves too much. Every human being comes into the world in a figurative ark floating on a figurative Nile. The mental states with which psycho-analysis deals are all interpreted as the representations of forgotten events. And if the representation be symbolic practically any state may be representative of any event. In the present case it is not possible to check back to see what the original events were. The events of early Egyptian and Hebrew history are lost—or rather the records have been tampered with for political purposes so that their original content is no longer recognizable. Freud believes that this condition is sufficient to justify his course of selecting from the evidence that which supports his thesis and ignoring that which contradicts it. This is the weakest point in an otherwise erudite piece of research. There is a glossary and an index, but both are painfully brief.



SLEEP AND WAKEFULNESS as Alternating Phases in the Cycle of Existence.

By Nathaniel Kleitman. University of Chicago Press, Chicago. \$5.00. 9 x 6; xii + 638; 1939.

As the writer states in his introduction, sleep is often taken for granted as a part

of the routine of life. Everyone of us has to submit to the arms of Morpheus sooner or later, and since the phenomenon of sleep is so prevalent it is obvious that it should attract the attention of mankind and so give rise to numerous speculations as to its nature. Some of these speculations have been idle tales procreated by superstition and ignorance, while others have been based on experimental and observational experience. The author begins his treatise where Piéron in his classical work on sleep in 1913 left off. One may gather the extent of the research done on this problem since that time from the bibliography which contains 1434 titles, none of which appears in Piéron's book.

Sleep is not considered as the opposite of wakefulness, but a complement to the waking state, "the two constituting alternate phases of the same cycle, the one completing the other as the trough of a wave completes its crest." There is not a sharp transition from one phase to the other, but a more gradual transformation.

A list of topics discussed would make a formidable array. Needless to say, there is very little that is missed. The book starts with the functional differences between sleep and wakefulness and progresses through to the final part which is devoted to the theories of sleep. The author describes his interesting experiences in his retreat in Mammoth Cave where he and a co-worker attempted to modify the normal 24 hour rhythm to 21 and 28 hour cycles. Other topics are the pharmacology and hygiene of sleep, hibernation and hypnosis, pathological interferences to the normal sleep-wakefulness cycle, and experimental production and deprivation of sleep.

A useful addition to the literature.



PERSONALITY CHANGES AFTER OPERATIONS ON THE FRONTAL LOBES. *A Clinical Study of 32 Cases. (From the Neurosurgical and Psychiatric Clinics of the Royal Caroline Institute, Stockholm.)*

By Gösta Rylander. Einar Munksgaard, Copenhagen; Oxford University Press, London. Danish Cr. 15.00. 9½ x 6½; 327; 1939 (paper).

A report of a "follow-up" of 32 patients whose frontal lobes had been operated upon during the years 1931 to 1938 in the Neurosurgical Clinic of the Serafimer Hospital in Stockholm.

The main part of these examinations was given to psychiatric research, but, in order to throw as much light as possible on the postoperative condition, consideration was also given to the constitutional and neurological features manifested by the patients. But the chief question to be answered was: "Do mental changes arise after partial excision of the frontal lobes and, if so, of what kind are they?" Of the 32 patients, conforming to certain principles which the investigator deemed essential for his study, 31 had been operated on for tumors, 1 for an abscess; in 20, the operation involved the left frontal lobe, in 12, the right; 12 had a meningioma, 19 a glioma. There was a possibility of an incipient recurrence in 5 cases, although examination revealed signs thereof in only 1 case.

The following changes were found by comparing the mental conditions of the subjects at the time of the follow-up examination with their mental conditions before the onset of the illness:

1. Emotional changes occurred in 30 cases. These changes are revealed in a diminished inhibition of affective responses in 15 cases and in a displacement of the habitual feeling level in 28 cases, in 20 towards euphoria and in 8 towards depression.
2. Changes in volitional and psychomotor activity occurred in 22 cases. 14 patients show restlessness and 12 deterioration of initiative and interest.
3. Intellectual changes, mainly involving the higher faculties, occurred in 21 cases. Specially selected psychological tests were given to all the patients and a control series of 32 non-operated persons. Statistical treatment of the results given shows the existence of significant differences between the two series, the operated subjects doing more poorly in the tests requiring the use of the higher intellectual functions. . . . There does not seem to be any distinct difference between the patients with left-sided and the patients with right-sided lesions.
4. Certain vegetative symptoms were observed but not frequently enough to allow any opinion on their significance.

In conclusion the author states that

Mental changes occur after excision of parts of the frontal lobes. These changes are exhibited in alteration of personality. Generally they are not of such degree as to destroy the subject's ability to lead a normal social existence, but they can be fatal to persons doing qualified intellectual work. . . .

Figures, tables, and a bibliography of 15 plates round out this investigation.

COLOR VISION AND COLOR BLINDNESS IN MONKEYS. *Comparative Psychology Monographs, Volume 15, Number 4, Serial Number 76.*

By Walter F. Gresler. The Johns Hopkins Press, Baltimore. 75 cents. 10 x 6 $\frac{1}{2}$; 38; 1939 (paper).

In this study the color vision of several species of New World (4) and Old World (9) monkeys was compared with that of man. One of the main purposes of the investigation was to obtain data which would aid in evaluating evolutionary theories of human color vision. Four measures of color vision were made: "discrimination of wave-length differences, proportion of two colors necessary in a complementary mixture, visibility curve, and test for dichromatic vision. Human and monkey subjects were tested under conditions as nearly identical as possible." Among the results obtained are the following:

Wave-length discrimination of Old World monkeys (a Guinea baboon, a green monkey, a pig-tailed monkey, and five rhesus monkeys) did not differ significantly from that of human beings. Discrimination of three New World cebus monkeys was significantly poorer in the red and yellow regions and about equal in the blue-green region. The discrimination of a New World spider monkey was equal to that of the Old World monkeys.

Compared to the average for three men, all animals tested required a greater proportion of red in a complementary mixture for it to match white. . . .

A test for dichromatic vision, given one cebus monkey, revealed a neutral band in the spectrum at 510 to 520 m μ . This result was taken to indicate that this animal, and probably the other two cebus monkeys also, had dichromatic vision.

Comparison of the color mixture data for cebus monkeys with similar data for human dichromats supported a conclusion that the color blindness of the cebus monkeys conformed to human protanopia (red-blindness).



TYPES, LEVELS, AND IRREGULARITIES OF RESPONSE TO A NURSERY SCHOOL SITUATION OF FORTY CHILDREN Observed with Special Reference to the Home Environment. *Studies from the Center for Research in Child Health and Development, School of Public Health, Harvard University, II. Monographs of the Society for Research in Child Development, Volume IV, No. 2 (Serial No. 21).*

By Eleanor Slater with the Assistance of Ruth Beckwith and Lucille Bobnke. Society

for Research in Child Development, National Research Council, Washington, D. C. \$1.25. 9 x 6; iv + 148; 1939 (paper). This study is divided into three parts: (1) Responses of young children to the new environment of an observation nursery school (5 chapters). Marked contrasts were observed in the tempo of their activities.

. . . Two opposite tendencies seemed to be at work Some children were very high in the number of their responses at the beginning of the period, and the number decreased sharply as the period progressed. Others were very meagre in their responses at first, and the number increased as the strangeness of the situation diminished. . . . Fifteen children out of the original 40 did not follow any simple pattern; they fluctuated from day to day, even from hour to hour, in the tempo of their activities and the nature and number of their responses. They were not a middle group; often they alternated between sharp extremes of activity and inactivity; at least, they showed occasional reversals of behavior.

(2) Responses to specific situations in an observation nursery school (4 chapters), and (3) Irregularities in the levels of response with special reference to changes in home environment (3 chapters). In an appendix are given sample record forms. The statistical data are exhibited in numerous tables and the study concludes with a bibliography of 52 titles.



THE MEASUREMENT OF ADULT INTELLIGENCE.

By David Wechsler. Williams & Wilkins Co., Baltimore. \$3.50. 9 x 6; ix + 229; 1939.

The author discusses the reasons why tests standardized on children cannot be used on adults. One of the most fundamental of these is "the fact that adult intelligence cannot be evaluated in the same terms as those generally employed in defining juvenile intelligence."

The contents of the book are in three parts, as follows: Part I, The nature and classification of intelligence. Different phases of this subject are: Nature of intelligence (10 pages); Need for an adult intelligence scale (7 pages); Concept of mental age and I.Q. (17 pages); Classification of intelligence (13 pages); Concept of

mental deficiency (6 pages); and The problem of mental deterioration (17 pages). Part II is concerned with the Bellevue intelligence scales under the chapter headings: Selection and description of tests (29 pages); Population used in standardizing tests (14 pages); Standardization and results (19 pages); and Limitations and special merits (8 pages). Part III gives in detail the manual of Bellevue intelligence tests. In three brief appendices are given statistics concerned with intelligence testing. These are followed by a group of intelligence quotients tables, record blanks, and a brief but well-planned index.



THE BOUNDARIES OF SCIENCE. *A Study in the Philosophy of Psychology.*

By John Macmurray. Faber and Faber, London. 7s. 6d. net. 7 $\frac{1}{2}$ x 5; 268; 1939.

The author of this work contends that science is limited, by which he means that there is a body of knowledge that cannot be apprehended by scientific method. He calls this body "knowledge of value" and contrasts it with scientifically acquired knowledge, or "knowledge of facts." His argument is that the mind cannot observe itself without prejudice; the observing mind behaves differently from the unobserving mind, therefore the mind cannot learn anything about its own behavior when not under observation. From this innocent premise all sorts of startling conclusions emanate, such as that if a science is true it cannot be true. The author also tells us that the scientist who verifies a theory learns nothing about its truth, but only about its validity. Verbal sophistries such as these have great significance to the metaphysician, but the humble follower of science is likely to feel aghast when they confront him.

Seven pages of index conclude the work.



THUS WE ARE MEN.

By Sir Walter Langdon-Brown. Longmans, Green and Co., New York. \$3.50. 8 $\frac{1}{2}$ x 5 $\frac{1}{2}$; 244; 1939.

This volume, constituted of a series of

lectures, is rather disconnected. The author calls it "Theme and Variations". The theme is that man is finding difficulty in taking the next step in evolution, this step being neither physical nor mental, but psychological. In order to make this advance we must understand the inner workings of the mind. Only in such a way can impulse be ruled, and many of our individual and social problems eradicated. The writer then goes on to deplore the present flight of reason demonstrated by modern music, poetry, and art. He thinks that medicine needs to return to the ideals of Aesculapius. Following this is a discussion of the causes of various types of neuroses.

The second section of the book attempts to analyse the minds of some well-known authors by interpretations of their writings. Closing chapters deal with a variety of subjects, including religion, art, and death.

The writer shows an amazing knowledge of literature, and the volume is well written. However, its principal claim for the attention of the reader lies not in any scientific contribution that it makes, but rather as a study of the author's reflections on life.



LIFE: A PSYCHOLOGICAL SURVEY.

By Sidney L. Pressey, J. Elliott Janney and Raymond G. Kublen. Harper and Bros., New York and London. \$2.50. 8 x 5 $\frac{1}{2}$; xxxiii + 654; 1939.

This is a textbook for a new type of introductory college course in psychology. As a background for a survey of problems dealing with the adjustment of the individual to his environment, the authors emphasize our socio-economic and cultural heritage, and the development of the individual both physically and intellectually from childhood to old age. The formal study of psychological principles is left to more advanced courses.



STUDIES OF ABNORMAL BEHAVIOR IN THE RAT. *The Neurotic Pattern and an Analysis of the Situation Which Produces It.*

By Norman R. F. Maier. Harper and Bros., New York. \$2.00. 8 x 5½; [10] + 81 + 16 plates; 1939.

This monograph, a report of experiments on behavior in rats under conditions of frustration, is a description of experimental neurosis in the rat. It is chiefly concerned with the analysis of neurosis-producing situations. A detailed report on the case history of each rat with which the author experimented is included as well as a number of excellent photographs of the subjects.



DE OMNIBUS REBUS ET QUIBUSDEM ALIIS

THE FIRST NEGRO MEDICAL SOCIETY. *A History of the Medico-Chirurgical Society of the District of Columbia 1884-1939.*

By W. Montague Cobb. The Associated Publishers, Washington, D. C. \$2.15. 7½ x 5; x + 159; 1939.

In 1862 slavery was abolished in the District of Columbia; in 1863 free schools for Negroes were opened; in 1866 Howard University was founded; and in 1868 the School of Medicine of Howard University was formally opened with a student body of eight and a faculty of five. It was from 1869 to almost the turn of the century that qualified Negro physicians made attempts to join the Medical Society of the District of Columbia. However, prejudice was strong in this essentially southern city, and the colored physician was not even professionally recognized by his white brethren, much less admitted into the same medical society. The Negro physicians, feeling that they should be admitted to the Medical Society, had their case brought before Congress and the American Medical Association. Suffice it to say that on one ground or another (not, of course, ostensibly racial) and after much controversy, the Negro physician was not admitted to the Medical Society. Therefore, in 1884, in order to secure for the qualified Negro physicians (as well as for any others qualified to join) the "advantages of regular meetings for medical improvement", the first Negro medical society, the Medico-Chirurgical Society of the District of Columbia, was formed.

This society met at irregular periods until 1917 when it became a permanent organization. Today it boasts a membership of 144 physicians out of the 170 in Washington.

The author gives not only particulars concerning the controversy but also tells of the founding of the Negro medical society, its subsequent history to date, and, in general, the status and work of the Negro medical profession in Washington from 1869 on. This report throws light upon the achievements of a small highly-educated group within a minority group set apart by reason of color and bi-racial ideology.



L'HOMME DEVANT LA SCIENCE. *Bibliothèque de Philosophie scientifique.*

By Lecomte du Nouÿ. Flammarion et Cie, Paris. 20 francs. 7½ x 5; 280; 1939 (paper).

Within the last third of a century revolutionary scientific discoveries have been made. Along with these, the writer claims, have sprung up a number of theories which threaten to become dogmas. He believes that the time has come to subject certain of our concepts to rigid criticism. The principal objection raised is to our atomic theory, which under a rigid materialistic inspection has a number of faults. How can we receive a satisfactory answer to our problems when the basis of our material universe rests on such shallow concepts? The only truly sound basis of science is experimentation with everything expressed in hard and fast mathematical terms.

The writer discusses the problem of the religious and scientific points of view. He says that since neither represents the whole man, one must have a combination of the two.



LONG ISLAND SEAFOOD COOK BOOK.

By J. George Frederick. Recipes edited by Jean Joyce. The Business Bourse, New York. \$3.00. 7½ x 5½; [4] + 324; 1939. This entertaining and useful treatise, by father and daughter (-in-law presumably),

except for some 25 pages of introductory matter which serves no particularly useful purpose but is harmless, is filled with recipes for cooking seafood of all sorts. Many are excellent—indeed the proportion of bizarre extravagances that are insults to honest fish, crustacea, or molluscs seems definitely smaller than usual in specialist cook books. But we find in the book no sufficiently impressive warning advice against the cardinal sin in nearly all seafood cookery, which is *overcooking*. Because of the prevalence of this obscene and immoral vice few people know the *real* and supernally delicious taste of lobster, for example. It is not in the least like the taste of either leather or rubber.



1939 BRITANNICA BOOK OF THE YEAR.

A Record of the March of Events of 1938.

Prepared under the Editorial Direction of Walter Yust. Encyclopaedia Britannica, Inc., Chicago and London. \$10.00. 10½ x 8; 748; 1939.

Prefaced by a calendar of the occurrences in 1938 this volume presents a comprehensive survey of the events of that year in all countries and in all fields of endeavor, from advertising to zoology, alphabetically speaking. It is liberally illustrated with photographs and cartoons. The frontispiece depicting a man with a gas mask entering a safety shelter and surrounded by soldiers and implements of warfare and the principals of the Munich pact, strikes

a sombre note to begin with, but happier progress is reported in other matters.

Although this new series of yearbooks is intended to bridge the gap between editions of the *Encyclopaedia Britannica*, it will be found a permanent as well as timely addition to the library. The volume is indexed.




GERMAN-ENGLISH SCIENCE DICTIONARY for Students in the Agricultural, Biological and Physical Sciences. First Edition.

By Louis De Vries with the Collaboration of the Iowa State College Graduate Faculty. McGraw-Hill Book Co., New York and London. \$3.00. 7 x 5; x + 473; 1939.


This is the most complete handy-sized lexicographical aid to science students that we have seen. The English meanings are well-chosen, specific uses noted, and for most plants and insects Latin as well as common names are given. Abbreviations are included. A selection of words was necessary due to the number of sciences covered, and "not all the names of animals, plants, insects or chemical compounds have been included, since each subject would make a dictionary of its own." There are, however, 48,000 entries.

The one unfavorable criticism of the book we have to make is that the glossy paper on which it is printed is not suitable for long hours of study under artificial light.





THE QUARTERLY REVIEW *of* BIOLOGY



AUDITORY PERCEPTION IN INSECTS, WITH SPECIAL REFERENCE TO THE COCKROACH

By PHIL RAU

Kirkwood, Missouri

DO INSECTS HEAR?

MANY insect species of various orders are capable of giving forth sounds. These sounds differ greatly in their nature, and are produced by various activities and by the use of manifold mechanical devices of the body.

Some of these insects that create sounds have organs which, from morphological and experimental investigation, are generally considered to be organs of hearing; there are other sound-producing insects upon whose bodies no organs of hearing have been found. Yet other species of insects are considered dumb because they have no organs of hearing and also are unable to create sounds, at least such as can be perceived by the human ear. There are still other insects that are known to possess organs of sound perception, even though they themselves create no sounds audible to the human ear. It seems logical to assume that sound-perception should be the complement of sound-production, or at least to expect that the

functions of voluntary sound-production and of sound-reception will exist together and not separately.

A survey of the literature of these two phases of the subject reveals the startling fact that the references on sound-production out-number those on sound-perception by at least twenty to one. The reason for this is that it is far easier to describe what an insect does and how it behaves than to tell how it feels and what it perceives. The result is that all present-day naturalists agree that some insects are capable of making sounds, but not all of them will agree that insects actually hear sounds that they or others create. It is now about fifty years since the subject of auditory perception in insects came into prominence. Students have been prone to decline to attribute this ability to insects, sometimes even in the face of the evidence from excellent experimental work, and some of the writers go so far as to refuse to concede hearing even in those insects which possess well-developed tympanal organs, and have no patience with even

the hypothesis that the so-called "dumb" insects—those in which neither stridulating nor hearing organs have yet been discovered—may have the ability to respond to sound-vibrations.

One might well think it logical to suspect, when a male cricket sings and the female comes to him, that she is attracted by his song. The criticism generally is that the experimenter has not absolutely ruled out the senses of sight and smell. One would also think that when an insect responds to sounds artificially created, it reacts to them by the sense of hearing. But the objection here again is that they may have been influenced by tactile stimulation. The work on the hearing of insects which has been done in the last twenty years has to a large extent mastered these criticisms, yet we often come upon statements which indicate that the newer work has been overlooked.

Lutz (1924) questions whether the sounds produced by insects have any more purpose than the snoring of a man when asleep, or the rattling of an automobile. He says (p. 333),

"insect sounds are not made for the purpose of being heard by human ears. Whether the insects themselves hear these sounds is the important question and one that has not been—possibly cannot be—determined beyond all doubt." Again (p. 367), "I am not aware of a single experiment that has furnished indisputable evidence of communication between insects by means of sound."

Washburn (1926) is likewise parsimonious in giving insects credit for sound perception. There are three editions of her ever popular book, *The Animal Mind*, and the opening sentence in her chapter on the hearing of insects is the same in all of them. "The sense of hearing in insects is also problematical." In spite of much new data published during the nineteen years that have elapsed between the first and the third editions, the space

devoted to this topic has increased to the extent of only one page.

As late as 1934, we find in the college text by Warden, Jenkins and Warner, entitled *Introduction to Comparative Psychology*, this statement (p. 144):

"Many of the insects possess chordotonal organs in both the larval and the adult stages, and these are commonly regarded as phonoreceptors. In most cases, however, these organs are very simple, and it appears unlikely that they serve auditory functions. The behavioral evidence . . . is against the view that the simple types of chordotonal organs are phonoreceptors." They take exception to this, in a reserved way, when they continue, "The only positive evidence for hearing in insects that is entirely trustworthy is that relating to crickets, grasshoppers, katydids, locusts and related forms, which are known to possess highly complex chordotonal organs. It is interesting to note that these forms are also stridulating types."

Since much diversity of evidence and opinion exists in this field, I have attempted to bring together a survey of the literature on this subject.

One may hardly speak of hearing in insects without touching upon the still larger subject of the organs for the perception of sound. References to the organs of hearing in insects I have omitted from this discussion. A comprehensive review can be had in Chapter 6 of Imms' *Recent Advances in Entomology* (1931). Likewise the literature on sound production in insects, which is a large one indeed, has also been for the most part omitted. Only those works are included which contain material on sound perception as well as sound production. Even all references to works which support sound-perception on morphological grounds only have been omitted. If an insect possesses tympanal or chordotonal organs, it seems quite likely that it hears sounds; this alone, however, is insufficient proof, in my opinion. The work, to be included in this review, must also cover observa-

tional or experimental data to show whether or not the insects hear sounds.

Ants

Most species of ants produce no sound that is audible to the human ear, although Emery (1893) reports certain East Indian species that make a loud, hissing noise when disturbed, and some species are said to chirp.

Janet (1893 and 1894) maintains that ants of the Myrmicidae make stridulating noises. Forel (1930, p. 215), says, "as far as I know there is only one ant, *Megalaponera foetens* of Africa, which stridulates in a fashion that is clearly perceptible to our ears, but many of the Ponerinae and Myrmicinae have stridulating organs." None of these three investigators has experimented to learn whether or not these stridulations are heard by other members of the colony. Wheeler (1910, pp. 512-514), however, not only shows that the stridulatory organs are well developed in the Ponerinae, Myrmicinae, and in a rudimental form in the Dorylinae, and that the ants possessing these organs emit very shrill sounds, usually of so high a pitch as to be inaudible to us, but that these sounds are means of communication ignored by many authors. In contradiction to the view of Forel and others who deny hearing in ants, "several authors (Metcalf, Weld and Wasmann)," writes Wheeler, "have recently maintained that ants do perceive aerial vibrations." Wheeler himself at one time took this stand when, on actually watching the sound producing proclivities of ants, he says (1903),

"I have also virulently expressed myself in favor of such a view." "Stridulation readily explains the rapid congregation of ants (Myrmicinae) on any particle of food which one of their number has found, for the excitement of finding food almost always causes an ant to stridulate and this attracts other

ants in the vicinity. It also explains the rapid spread of a desire to defend the colony when the nest is disturbed. This is especially noticeable in species of *Pheidole myrmica* and *Pogonomyrmex*. It is the secret of being able in a short time to catch ants like *P. molefaciens* in great numbers by simply burying a wide-mouthed bottle up to its neck in the mound of the nest."

The stridulation of one or two ants that fall in at once attracts other ants which hurry over the rim and "forthwith swell the stridulating chorus till it is audible even to the human ear." If the bottle be corked and shaken for the purpose of still further exciting the contents, and then held over another *Pogonomyrmex* colony whose members are peacefully sauntering about on the dome of the nest, "the wildest excitement will suddenly prevail, as if there had been a call to arms—or to dinner." Wheeler, in describing the stridulation of the Texas leaf-cutting ant, *Atta fervens* (= *texana*), says,

"Even more remarkable is the stridulation" in a colony of these ants. "Here the different ants, from the huge females through the males, large soldiers and diminishing castes of workers to the tiny minims, present a sliding scale of audibility. The rasping stridulation of the queen can be heard when the insect is held a foot or more from the ear. To be audible the male and the soldier must be held somewhat closer, the largest workers still closer, whereas the smallest workers and minims, though stridulation may be seen from the movements of the gaster on the post-petiole, are quite inaudible to the human ear." He goes on to say that it is not at all improbable that "all this differentiation in pitch, correlated as it is with a differentiation in the size and functions of the various members of the colony, is a very important factor in the cooperation of these insects and ants in general. The contact odor sense, important as it undoubtedly is, must obviously have its limitations in the dark subterranean cavities in which the ants spend so much of their time, especially when the nests are very extensive like those of *Atta*."

At one time Wheeler believed that ants not only can hear, but that they communicate by means of sounds; but after the appearance of a paper by Fielde and

Parker (see paragraph below), he asserts that there is not sufficient evidence to warrant the assumption that ants can hear. However, he fully realized the importance of his observations on the reactions of ants to sounds made by other ants, for he says that if the views of Miss Fielde and Parker be accepted, we must suppose that *Pogonomyrmex* were thrown into agitation by vibrations passing from the bottle of stridulating ants, through his body, to the soil of the nest. At first it seemed more probable that the ants perceived the stridulation directly as aerial vibrations. However, despite the supporting evidence by Turner, Wheeler became influenced by this work and cast a note of doubt over the entire subject by finally saying it is extremely difficult to exclude the transfer to the ants of vibrations through the floor, table and walls of the nest, "and for this reason we cannot with the data at hand reject the statements of Fielde and Parker," and we shall be more within the bounds of accuracy "if we discuss the question from the standpoint of mechanical stimulation, rather than to set up questionable distinctions based upon human sensations." Thus he acquiesces, where he might well have stood his ground, on the basis that the sounds and reactions by the insects themselves in his field observations are a better test of their hearing ability than experiments in the laboratory.

It is interesting to note, in passing, the attitude of Sir John Lubbock (1929, p. 168), in the face of far more discouraging results than Wheeler's. After experimenting on the hearing of ants, bees and wasps with the loudest and shrillest noises that he could produce, and getting only negative results, he still believed that ants could hear, for he says, "On the whole, although the subject is still involved in doubt, I am disposed to think

that ants perceive sounds which we cannot hear."

And now to consider the work of Fielde and Parker (1904). They could not get any reactions from ants to aerial sound waves from a piano, Galton whistle and violin, which collectively gave a range of from 27 to 60,000 vibrations per second. The ants reacted, however, to vibrations reaching them through the soil and other solids. These vibrations were received through the legs, as they were perceived even when the antennae, head, abdomen and any one or two legs were removed.

Turner (1907) found that when ants are outside the nest they pay little or no attention to sounds, but when inside they respond to them with very active movements. This is true even when precaution is taken to prevent the sound waves from reaching them through any medium other than air. Turner's work was carefully planned with reference to eliminating tactile perception, and the results show that *Formica fusca* and *F. sanguinea* are sensitive to vibrations of the air "which to human ears would be sounds." These two species are not known to stridulate, but they respond to vibrations as low as 256 and as high as 4138 per second.

The responses were in the form of zig-zag movements, and were usually slight for pitches higher than 3000 vibrations per second, and sometimes to other pitches; but to most pitches under 3000 vibrations per second the ants usually responded in a pronounced manner, usually darting about as though much excited.

Wasmann (1891) has noted reactions of ants to sounds, and, like Turner, worked with them within the nests. Washburn (1926) thinks he was not careful to exclude the possibility of vibrations other than sound waves influencing their behavior, but if a translation by Staeger (1928) reviewing the work is correct, Wasmann's work and method are legit-

imate. He experimented on a colony of "forest ants" in an artificial nest. Such a nest consists of a rectangular block of wood or plaster, closed on top with a glass plate. In this case the glass had been accidentally cracked, and he closed the crack with shellac. When the laquer was entirely dry, he passed a steel needle lightly across it, whereupon the ants in the nest suddenly stretched out their antennae, agitated them and tried to touch the glass above them by raising the fore part of the body. The movement was so sudden and general that he repeated the test several times, always with the same result. But if he rubbed the same place with some smooth object, as a paper knife, the ants paid little attention. As soon as he again scratched the shellac with the needle, thus evoking an extremely fine, high-pitched stridulation, the movement described above was repeated; this, he concluded, was reaction to sound waves. The fact that the ants reacted only to this high-pitched, fine sound may indicate that it resembled something of biological importance to them, probably of a friendly nature, since they reached for it instead of fleeing from it. If their movement was due to a shaking of the nest, it would also have happened when a paper-knife or other object was used. In the light of work done on hearing among other insects, we can appreciate Wasmann's work today better than when it was done nearly fifty years ago.

Weld (1899) has experimented on *Crema-togaster lineolata*, *Lasius americanus* and *Apheogaster* sp., and Metcalf (1900) on a small black ant, to the conclusion that ants perceive aerial vibrations.

Eltringham (1933, p. 75), says that Baier experimented with the ant *Myrmica rubida* and obtained responses to some notes on a violin.

Lubbock (1929, p. 168), says that St. Fargeau attributed the power of hearing in ants, as well as to bees and wasps.

In contrast to the foregoing reviews of the works of investigators who are inclined to credit ants with the sense of hearing, we have a host of students who protest against it, some of them almost vehemently. Some of them do so on grounds of observation and experiment, some on morphological grounds, and some merely on theory.

Huber (1820) says that ants are quite deaf, but offers no experimental proof.

Lubbock (1929) likewise found that *Camponotus ligniperdus* took no notice of any sound which he was able to produce. Likewise the tests on *Lasius*, in which he wished to find if possible whether ants have the power of summoning one another by sound, he could not find any communication transmitted. Even after this he remained skeptical, and maintained that ants, "even if deaf to the sounds we hear, may hear others to which we are deaf."

Forel stood firm throughout his long life in refusing to credit insects with the sense of hearing. In his early work, probably done in the 1880's and brought together in Forel (1908, pp. 109-110), he concludes:

"What may be considered as proof of hearing appears to me to rest, with a few exceptions, almost certainly upon mechanical vibrations of the air or ground. These are simply perceived as such by the tactile organs of insects, . . . but it is not right to call such sensations hearing." In a work appearing just a few years before his death, Forel (1930, pp. 215-219) says, "Apart from crickets, some locusts and grasshoppers, the other insects appear to remain deaf as soon as we eliminate the mechanical shocks to which all of them are highly sensitive. I have shouted and whistled with all the force of my lungs equally close to various insects while protecting them from my breath. So long as they did not see me, they paid no attention." "We can hardly give much credence to Leon Dufour, who thought he had proved hearing in crickets because they ceased their

chirping when he struck the ground with his foot. . . . He forgot that the deaf and dumb feel the rumbling of a carriage at a distance." "Sound waves, especially those of low-pitched sounds, bear a much closer resemblance to powerful mechanical shocks than luminous caloric or electrical waves. Hearing has therefore a fundamental connection with touch." "All these facts, so it seems to me, combine to show that if insects, particularly ants, have any hearing, it takes place in some way different from our own, even in crickets and locusts. We are justified in assuming that they perceive the stridulations of their species as shocks at a certain distance." And finally, waxing a bit facetious, "This is all we know about the ants' sense of hearing. You will admit, dear Reader, that it is very scanty, and will be prepared to exclaim, as I did, when I had refuted the long dissertations of so many authors on the seat of insect hearing: 'Heavens! What a large number of ears for such a deaf folk!'"

Myers (see Lubbock, 1929, p. 331), says Forel has long lent the weight of his authority as entomologist and psychologist to the opinion that not only ants, but insects in general, are deaf.

It is true that many experiments clearly indicate in insects an entire unconcern with vibrations which seem very loud noises to us; it is probable also that their very small size and nature of their framework—a rigid exoskeleton—make them sensitive to vibrations imperceptible to us, which they perceive by other means than hearing in the strict sense of the term. There is, however, considerable experimental evidence that insects can hear, and there are on the one hand complicated structures devoted exclusively to the production of special sounds, and on the other hand exceedingly complex organs to which it is difficult to assign any other function than that of hearing.

Bees

Lubbock (1929) failed to get hive bees to respond to artificial sounds. Bethe (1900) and Forel (1888) believed bees to be deaf. Armbruster (1914, 1922) reports that bees do not hear the sounds that they make, and experiments by Kröning (1925) show that bees do not hear artificial sounds of the same pitch range as their own. McIndoo (1922) is

skeptical about hearing in bees, because their only possible auditory organs, the chordotonal, lack the external tympanum present in crickets and katydids. In his conclusion, despite the fact that he has added nothing experimentally or observationally on sound perception, he expresses agreement with Forel's interpretation.

Despite these dissenting notes, one can hardly laugh off the observations of Buttel-Reepen (1907), a keen observer of bees. He says odor is not the only factor in communication among bees, for when the colony notes the absence of the queen, there is always a change in the usual characteristic sound in the hive. There is therefore

not the slightest doubt in my mind that bees communicate with each other by sound. The tone of peace attracts hive mates or quiets them; the louder buzzing excites them; it disappears if the queen is given back. At the same time the whole character of the colony changes, and queenless, irritable bees become quiet and peaceful and again take up their life work, which was laid aside during the excitement. We must admit the possibility of communication between bees by sound, therefore of hearing capacity and sound sensations. Each bee has the instinct to join in the tone of discontent if it hears it; therefore if the absence of the queen is noticed by one bee, the agitation is very quickly propagated throughout the colony.

Mrs. Comstock (see Lutz, 1924), in her *How to Keep Bees*, says,

The belligerent attitude of the queens toward each other seems to have been so strong an emotion that a voice has been developed to express it. This note must be heard to be understood; as nearly as I am able to spell it, it is 'tse-ep, tse-e-e-ep, tse-e-ep, tsep, tsp, ts', in a sort of diminuendo. She makes this noise when she discovers another queen cell; if there is within this cell a full-fledged queen, she pipes back, but it sounds quite different, and is more like 'quack, quack'. This piping of the queen is especially evident before an after-swarm is to issue. The queen will also pipe when the bees gather about and try to ball her. In this case the note is one of righteous anger. Her wings vibrate tremendously

while she is piping, but she can pipe quite vociferously after her wings have been entirely cut off.

Cheshire (see Lutz, 1924) cannot but regard the negative results of Lubbock's observations as inconclusive, since "tuning-forks, whistles and violins emit no sound to which any instinct of these creatures would respond." Should some alien watch humanity during a thunder storm he might quite similarly decide that thunder to us was inaudible.

"Clap might follow after clap without securing any external sign of recognition; yet let a little child with a tiny voice but shriek for help, and all would at once be awakened to activity." "In practical matters, the hearing of bees is not only often obvious, but must be taken into account—e.g., when a swarm is about to be transferred to its permanent abode from its temporary one, many will stick to the sides of the latter after the bulk have been thrown out, and these, by their buzz, will distract those that are running in at the new hive door. The removal of the stragglers to a distance will end the disturbance; which will be renewed if they be returned to their former position."

He relates another significant incident, witnessed by several people. Where several swarms of bees were being handled, nearly a pint of lost bees had collected for mutual comfort on a piece of damp canvas at the bottom of a tent-pole. No sooner did the bees in the skep on the table above set up the well-known roar than those on the canvas, hitherto so very quiet, faced about and unhesitatingly went up the pole and settled on the outside of the skep. He concludes: "This circumstance I remember as offering to all who witnessed it conclusive evidence of hearing. Piping queens, whatever be the cause, seem to point to a sense of hearing, for it appears to be a sound made for an object and not the result of some necessary movement."

Wasps

The Peckhams (1887) carried on some experiments on the hearing of the social

paper-making yellow-jackets, *Vespa germanica*, and obtained negative results. They stood one foot away from the nest at a time when the wasps were entering rapidly (two hundred in five minutes), and made several kinds of noises, shouting, whistling and clapping of hands, but the wasps took no notice. We should not forget that probably these sounds had no life significance for them.

Latoste (1929) offers experiments to show that *Vespa crabro* is not deaf, although it may not react to sounds when exhausted or when subjected to repeated stimulus.

In Panama there is a social wasp, *Synoeca surinama* (Rau, 1933, pp. 122-123) with a severe barbed sting. When danger threatens, these wasps send out a musical warning before launching an attack. The use of the barbed sting means the death of the wasp; I believe this is why they are reticent about attacking an intruder without first trying to frighten him away with their noise. The combs of the nest, fastened vertically against the tree-trunk, have a covering of heavy, corrugated cardboard which serves as a sounding-board when the inmates beat their wings against the inner surface of it. Thus they have built up an elaborate and effective defense mechanism on the use of sound, but I can offer no experimental proof that they themselves hear these sounds which they cooperatively produce.

For the social wasp, *Polistes pallipes*, Rau (1939) found that when sound waves of 2000 vibrations and 6000 vibrations per second were continuously focused on workers while they were asleep, their "abdomens pulsated rhythmically while simultaneously the sting moved in and out." The wasps responded thus, apparently, without waking.

Ormerod (1868), p. 74, is quite certain that the British social wasps not only do

hear, but that they also "make certain noises with the intention of being heard."

Lutz (1924, p. 361), says of the cicada hunting wasp, *Sphecius speciosus*, that since she catches about as many female cicadas as she does males, it indicates that she does not hear the sounds produced by the males.

Termites

Andrews (1911) has conducted experiments which, he thinks, indicate that termites respond to concussions of air as such. The noise of thunder and the blasting of rocks would send thousands of them scurrying to their nest. Even the clapping of hands, which probably was too light to jar the stone upon which the nest rested, would produce the same effect. He interprets this, not as a case of audition, but merely that termites seem to respond to certain concussions of air.

Emerson (1928) reports that certain sounds by termites have often been heard, and it is also well known that the termites possess so-called ears on the tibiae. In *Nasutitermes guyanae*, he finds soldiers and workers made no response to any noises he made, even when only six inches away from them; however, when he touched the nest, even delicately, "the excited response was very definite." He has heard sounds produced by workers of *Armitermes percussiens* when the colony was disturbed, and he thinks these probably are of use "as a warning to other members of the colony." These sounds are audible to human ears even five or six feet away. With an apparatus especially constructed for the purpose, Emerson tested the substratum vibrations of *Reticulitermes flavipes*. Some of the soldiers resting on the wood were disturbed and were thus stimulated to hammer their heads upon the substratum. The noise was so great that it sounded unpleasantly

loud through the ear phones. "Thus it can be seen that termites in widely separated groups have the power to transmit substratum vibrations, and the experiments indicate that they have the power to hear vibrations through the substratum."

Beetles

Of the death-watch beetle, which produces sound by tapping with its head or abdomen, Lubbock (1888, p. 66), says, "if a male death-watch ticks and there is a female within several yards, she returns the tap and they approach one another slowly, tapping at intervals until they meet."

Tower (1906) observed the potato beetle reacting to the sound of a tuning-fork. He says, p. 225, "if a slight noise be made, the insect will pause, if the noise be continued, they seek safety in flight and if it is greatly increased, they assume the so-called death attitude."

Will (1885) mentions his experiment on the beetle *Cerambyx scopuli*. He enclosed a female in a box, and at intervals irritated her with a pin and caused her to stridulate. The male, six inches away, would at these time grow restless and move toward the box.

Darwin (1894), in discussing stridulation in beetles, cites several instances where the males stridulate "in order to call or to excite the females." Beetles stridulate under various emotions; some stridulate "in anger or defence," others "from distress or fear," "to encourage the female in her work," "to frighten enemies," and finally, "it is probable that the two sexes of many kinds of beetles were first enabled to find each other by the slight shuffling noise produced by the rubbing together of the adjoining hard parts of their bodies," but not in one

instance does he prove that these sounds were heard by the insects themselves.

Bugs

The back-swimmers, *Buena limnocastris*, began to chirp almost as soon as Hungerford (1934) brought them into the laboratory; even in the obscure light of the pail, he says, it was apparent that the females inspired the singing.

They sang their courtship songs at all hours of the day or night, on cloudy days, on clear days, in sunshine or shadow. In the aquarium containing three pairs there were times when all the males were singing at once. . . . The male singles out a female, maneuvers for a position some distance beneath and behind her, and begins a ticking sound as he slowly cruises nearer the object of his desire, his body aqiver with emotion. When within a half-inch or so of the female, the ticking changes to a hum, and is followed by a sudden dash to embrace her.

For the water-strider, *Gerris remiges*, Essenberg (1915) finds that when a door is slammed or a metallic sound is made, these insects immediately respond by darting backward. If buzzing insects are dropped into the water, the striders rush toward them, but if the proffered insects are dead, they make no response. These experiments were tried also with blinded *Gerris* with the same results, the sightless striders moving from all directions toward the source of sound. These facts induced Essenberg to believe that water-striders can hear.

Graber (1882) found that a water insect, *Corixa*, was undisturbed by a bone disc being pushed toward it in the water, but gave decided reactions when the disc was connected with an electric bell.

Graber (see Lubbock, 1888, p. 75) also made some ingenious experiments on the water-boatman, *Corixa*. He placed them in a deep jar of water at the bottom of which was a layer of mud. He dropped in stones which sank in the mud, but the

beetles, reposing on some weeds, took no notice. He then placed a piece of glass on top of the mud and dropped in stones as before, thus making a noise, although the disturbance of the water was the same as before. The water-boatmen than took flight.

Book lice

Pearman (1929) says that sound production by *Clothilla pulsatoria* has long been known. The female taps with its abdomen at the rate of five or six a second. "The sounds produced are undoubtedly the mating calls of the female."

Flies

Hancock (1911, p. 215), says some male *Tabanus* flies have been able to win females by their humming sound. Müller has seen an *Eristalis* courting a female by hovering above her and flying from side to side, making at the same time a high, humming sound.

The striking work of Mayer (1874) on adult mosquitoes frequently appears in discussions of the hearing of insects. He fastened a live male mosquito to a glass slide, and had a series of tuning forks of different pitch sounded.

When the U_4 fork of 512 vibrations per second was sounded, many of the antennal hairs were set, sympathetically, in strong vibration. Tuning forks of a pitch an octave lower and an octave higher also caused more vibrations than any intermediate notes. The male mosquito's auditory hairs are specially fitted to respond to, i.e., be stimulated by notes of a pitch produced by 512 vibrations. Those auditory hairs are most affected which are at right angles to the direction from which the sound comes. From this it is obvious that, from the position of the antennae and the hairs, a sound will be loudest or most intense if it is directly in front of the head. If the mosquito is attracted by sound, it will thus be brought straight head on toward the source of the sound. As a matter of fact, Mayer found the female mosquito's song to correspond nearly to U_4 , and that her song set the male's auditory hairs into vibration.

With little doubt, comments Kellogg (1905) the male mosquitoes find the females by their sense of hearing.

Cicadas

Fabre's experiments (1919) on hearing in the cicada is often cited by those who wish to discredit sound perception in insects. A half-dozen cicadas refused to stop their singing when he fired off thunderous explosions of gunpowder from two cannon which he had borrowed from the municipal artillery and placed under the tree. With a flourish he says, "The mighty explosion has in no way affected the song of the cicadae," and concludes that they are "extremely hard of hearing, and we may apply to him the familiar saying, 'to bawl like a deaf man'." Fabre forgets for the moment that those sounds have no significance to them, as the noise of a bird, a lizard or any natural enemy of cicadas might have had. Fabre lapses into another of his frequent paradoxes when he says in the same breath, "I see in the grasshopper's fiddle, the frog's bagpipes, and the cymbals of the Cacan, but so many methods of expressing the joy of living." But how could sounds purposely made, produce joy unless by being heard?

Myers (1929, p. 200) and Myers and Myers (1928), after much careful observation of a number of cicada species in different parts of the world, say that "we may legitimately conclude that cicadas hear."

Imms (1931, p. 125) remarks that in the Cicadidae the presumed absence of any receptor organs for sound vibrations had for many years been the outstanding difficulty in interpreting the function of highly developed powers of sound production. It was not until 1923 that Vogel in Germany proved by histological studies

that true tympanal organs are present in both sexes.

Richards (1927) cites Poulton's (1896) observation that the males of the cicada *Monometopa insignis* call in rivalry in close proximity to the females. In this species also there was evidence that the sound had to be made for some time before the females became acquiescent. On one occasion the male attempted to copulate too soon, and was unsuccessful; he moved back to his original position and continued singing to the female who remained by him.

Another conspicuous bit of proof that cicadas perceive sounds is an article by Marlatt (1898), wherein he says that *Cicada septendecim* is heard between the hours of 11 and 3, but never between sunset and sunrise. However, on rare occasions when disturbed, they will start up singing in concert in the middle of the night. He quotes Prof. A. D. Hopkins, who noted an instance of this in West Virginia:

I was fortunate to hear the starting of one of these concerts on a clear, moonlight night in June. One male in an apple tree suddenly called out as if disturbed or frightened. His neighbors in the same tree were apparently awakened. One started the familiar song note which was at once taken up by numbers of other males, and, like the waves of a pebble dropped into still water, the music rapidly spread until it reached the edge of the thick woods, where it was taken up by thousands of singers, and the concert was in full blast as it had been the previous day. This continued for a few minutes until all had apparently taken part and the song had reached its highest pitch, when it began to gradually subside, and in a short time silence again prevailed.

Moths and butterflies

Snodgrass (1928) mentions that Peter has recorded evidence of perception of sound by a female moth, *Endrosa remosa*. The males of the species, he says, make a cracking sound as they fly, and when one comes near a female sitting quietly

and hidden in her usual manner, she bestirs herself with a trembling and fluttering motion as long as the male continues his sound-making. After mating the females no longer respond to the sounds of the males.

Snodgrass also cites Eggers' (1925) experiments on Noctuid moths, *Agrostis pronuba*. These moths possess tympanal chordotonal organs on the base of the thorax, and respond to loud sounds, especially to the sharp, squeaking noise made by the turning of a glass stopper in the neck of a bottle. They react to the sound with a movement of fright, starting to fly or to run, but on the cessation of the sound they fall back into the position of repose. Destroying one tympanum and its chordotonal organ has no effect on the reaction, but if the organs on both sides of the body are destroyed the moths will no longer react to sounds.

Turner (1914) and Turner and Schwarz (1914) have done excellent experimental work on the hearing of Saturniid moths in the laboratory, and on *Catocala* moths in the open field. These moths are not known to make sounds. Turner finds that of four species of silk-worm moths, three respond readily to a large range of sounds, and the fourth, *Teia polyphemus*, normally does not. By causing *polyphemus* to associate punishment with certain sounds it can be induced to respond to those sounds. In their outdoor tests with *Catocala* moths, they found several different species to respond to high notes, either by flying or by quivering the wings. By touching the insect at the moment when the whistle-tone was sounded, thus giving to the sound a life-significance, they trained some of the moths to react to a lower organ tone. These authors conclude: "It seems certain that all four species of Saturniid moths and several species of *Catocala* moths can hear."

"The fact that an insect does not respond to a sound is no sign that it does not hear it. The response depends upon whether or no the sound has life significance."

Heinrich (1909) remarks that he noticed a *Laurentia suffumanta* alight in a concert pavilion and remain quietly at rest while the brass band played three numbers, one of which was Wagner's *Götterdämmerung*. He also observed that certain Lepidoptera were more easily approached at twilight than when the sun was shining brightly, and he could not understand why this should be true if they were warned by a sense of hearing. He is convinced in all of these cases, that it is vision, not audition, that warns the butterflies and moths of danger.

Hamann (1909) was led to investigate the subject by the remarks of collectors that butterflies and moths undoubtedly hear. One man said that the noise caused by removing the cork from the cyanide bottle often caused the insects to fly away; to this Hamann replied that the net is usually placed beneath the insect at that time, and the sight of that may cause the insect's flight. To test the matter, he approached a tree in such a manner as to be invisible to an *Apatura iris* that was resting on it, and struck the tree with the bamboo handle of his net. To this the insect made no response, but as soon as the net approached it took flight. A repetition of the experiment with *Vanessa* yielded similar results. He also noticed that *Catocalas* which were not disturbed by the noise of a passing automobile flew upon the approach of man. These tests convinced him that butterflies and moths cannot hear.

Rothke (1909) thinks that butterflies and moths can hear sounds.

Richter (1909) made observations upon *Catocala pacta*, and is convinced that the crackling of twigs underfoot, and even

the slight noise made by removing the cork from his collecting bottle, disturbed the moth. In another article (1910), he made a comparative study of the auditory powers of the day-flying and night-flying Lepidoptera. *Limenitis populi* and *Sat. alcyone*, and species of *Apatura* and *Vanessa* made no response to sound so long as no visible object disturbed them. During a severe storm he noticed a number of *Sat. alcyone* perching on a limb. Neither whistling, the clapping of hands nor the shaking of the limb disturbed them, but as soon as the hand of the collector approached, they flew. A *Vanessa antipoda* was not disturbed by the shrill whistle and rumbling noise of a passing train. A night-flying *Catocala fraxini* made no response to the noises made by wagons, automobiles and bells of the ferry, but it responded readily to slight, high-pitched sounds. He suggests that the sounds to which they react are similar to those made by field-mice, bats and owls—sounds which for the moth have pronounced life significance. Richter is convinced that day-flying Lepidoptera are warned by visual, and night-flying forms by auditory, stimuli.

Collenette (1928) records an *Ageronia* responding to a noise made by birds. He noticed two small warblers fighting on the ground, and heard one bird frequently making a rapid, clicking sound with its beak. A butterfly, *Ageronia februa sabatia*, lighted on his coat, and each time the birds made the clicking noise the butterfly took a short turn in the air, and gave its characteristic clicking noise in reply. The sounds made by the bird and the butterfly were very similar, both in quality and speed of utterance. "The prompt response of the insect left no doubt that it was replying to the birds."

Eltringham (1933, p. 76) after reviewing the subject of hearing in insects,

including many Lepitoptera, concludes that there is little evidence that insects (other than grasshoppers and cicadas) can hear in a sense comparable with that faculty in the vertebrates.

They may be and sometimes are affected by sounds and respond to them, but in the majority of observed cases the action is probably more akin to a tactile sense of vibration than to a true auditory sense. It may even be a sympathetic vibration in response to air waves of a certain frequency just as a glass bowl or string of a musical instrument "will respond to air-borne waves of a frequency similar to that of their own natural periods."

I may say, parenthetically, that these conclusions are based on a study of insufficient literature; many important references (such as Turner, 1914) have been omitted which might have modified the complexion of the deductions.

Caterpillars

Minnich (1925), according to Eltringham (1933), experimented with the larvae of the butterfly, *Vanessa antipoda*. In response to sounds, they moved the anterior part of the body. They were affected by the human voice, a piano, organ, violin and tuning forks; pitches of 32 to 1024 were effective. As decapitated bodies and parts of bodies also responded, he concluded that the organs involved were certain hairs on the anterior part of the body.

Baier's experiments (1930) with larvae of the cabbage butterfly, *Pieris brassicae*, confirm these results.

Abbott (1927) carried on similar tests on caterpillars of the moth *Datana perspicua*. Definite responses were noted to air currents, sudden jars, and only two notes, C" (512 vibrations per second) and F sharp (728 vibrations). Larvae thus stimulated elevated the anterior and posterior regions of the body. During the experiments the larvae were protected

from air currents; they were several feet from the instruments, and vibrations from the substratum were eliminated. The caterpillars showed no response when the body hairs were covered with water, or when the body surface was anaesthetized with a 2 per cent solution of procain.

Minnich (1936) tested seven species of butterfly larvae and eight species of moth larvae, belonging to eight different families, and has found them to be responsive to sound. The response to sound of hairless forms he finds to be essentially the same as for the very hairy forms.

Short-antennaed grasshoppers, or locusts

Hancock (1911, p. 342), records the behavior of a male Carolina locust *Disosteira carolina*. It was seen to start from the ground, mount into the air three feet; here he balanced himself in midair for several seconds. At first his wings vibrated very rapidly, but toward the end of the flight they became slower, and then he dropped to the ground, where he joined two other males; all three had an active greeting, all taking part in the stridulating. This had the effect of attracting the male of the sprinkled locust, *Chloactis conspersa*, and in a moment he also joined in the jollification. "There seems no doubt but that the Acridians have a cultivated ear for grasshopper music, aside from its mere secondary sexual attraction."

Fulton (1928) observed the sound-making, and incidentally the hearing, in a species of grasshopper, *Circotettix coconino*, in Arizona. This species "effects periodical community outbursts of a loud, rattling noise made with the wings while putting on an exhibition of stunt-flying." At intervals of about one-half hour, Fulton would hear some of these grasshoppers flying in the distance. The sound would approach, and suddenly

several of the insects nearby would take to the air, and make the desert ring with a terrible clatter. Then they would settle down and he would hear the wave of disturbance passing on to other parts. He says in conclusion, "How do these grasshoppers, resting on the ground, often under the plants, know when it is time to perform their aerial antics, except by a sense of hearing?"

Richards (1927) remarks that in some grasshoppers, *Psophos stridulus* and *Stauroderus scalaris*, there is an additional mechanism by which the wings make a loud rattle when the male, who is more aerial than usual, is traveling through the air. There is ample evidence that the males stridulate to excite the females and also sometimes in rivalry with one another.

Poulton (1896, p. 233), says that the male of *Psophos stridulus* has a special call which he utters only in the presence of the female. His observations also show that in several species of grasshoppers only the male stridulates at all, or at least persistently, in the presence of the female and that sometimes two or more males will stridulate near the same female.

Weaver's studies (1935) are summarized in *Biological Abstracts* as follows:

The threshold of auditory sensitivity of four grasshoppers was determined from the electrical response of the nerve leading from the tympanal organ. These insects proved very insensitive to low frequencies. Near the lower limit it required for threshold stimulation a sound of about 95 db. above human threshold. With rising pitch the auditory sensitivity increases until at 10,000 cycles it closely approaches that of man. Beyond that point the sensitivity decreases until the upper limit is reached around 20,000 cycles.

Faber (1929) is summarized in *Biological Abstracts*:

The males of each species produce a certain number of other sounds in addition to their ordinary

audible expressions. For example, *Chorthippus parallelus* shows seven kinds of stridulations which express four different conditions: the ordinary song, the rival song, the courting song and the mating song. In courtship almost all species show a striking diminution of tone strength as compared with their other sounds. In *Stauroderus biguttatus* at the height of courtship there appears a special form of stridulation which produces a scarcely audible sound. Rivalry of males was noted for *S. mollis*, where there is a reciprocal answering of males. The exchange of rival songs occurs in all species after reciprocal hearing. In *S. bicolor* the exchange of the chirps of the males has also been shown to be of the nature of rival songs which can be induced through imitation. The importance of the rival song is that it increases the eagerness of courtship and causes a collection of males around a female.

Katydid

Hancock (1911, p. 102), observed a male "arboreal" katydid, *Cyrtophylum perspicillatus* one September, commencing to stridulate each evening between 6:15 and 6:30, and no artificial sounds or mimicking could induce him to start earlier. When this one in the tree began to sing, another male which was kept in captivity would start almost simultaneously with him, but when the latter was kept indoors, so outside sounds were excluded, he failed to show any sympathetic reaction. Hancock says that it certainly seemed that he was awakened to activity by recognizing his neighbor's sounds.

Discussing the "swordbearer" katydid, *Conocephalus attenuatus*, Hancock (p. 337) exclaims: "What a picture this cone-head katydid presents during the height of his musical performance. In answering his rivals his enthusiasm seems to rise to supreme heights, as signified by the energy exercised in rubbing his wings together in rapid vibration."

Allard (1929, p. 576), verifies Caudell's statement that the female conehead, *Neoconocephalus robustus*, when handled, stridulated like the males. He finds also that the females of other species of katy-

dids in the field emit a characteristic call of their own. "These call notes appear to be of the nature of true sex calls or invitations to the males, for a number of these in every instance at once congregated about her," some of them flying from the shrubbery near by. Allard has observed this behavior in the females of the bush katydid, *Phaneroptera curvicauda*, the round-winged katydid, *Amblycorypha rotundifolia*, and the larger angular-winged katydid, *Microcentrum rhombifolium*.

He also says that he came upon one of the most remarkable instances of perfect synchronism in a group of cone-headed katydids, *Neoconocephalus exiliscanorus*, rasping out their "dzeet—dzeet—" From time to time one or another would pause after the usual series of 18 to 25 notes.

When it again joined the chorus its notes were always perfectly timed to accompany those of the other singers. Here for a long period of time this dropping out and taking up the musical play was indulged in, but always with the same perfect synchronism with its fellows.

Of the bush katydid, *Phaneroptera curvicauda*, he says,

I had at one time a female in captivity in my bedroom which would lisp out responses to my own lisping mimicry as often as I dared stimulate it. In tests of this katydid I stepped away slowly the entire length of the room, lisping so low as barely to hear it myself, and yet it heard it and responded promptly." He is thoroughly convinced that insects of this group hear sounds, for he says, "That all insect instrumentalists hear their own sounds I have not the slightest doubt, for I have positive evidence that their hearing is exceedingly acute."

Fulton (1928) says that "the fact that certain species of Orthoptera synchronize their notes seems to me conclusive evidence that they can hear each other." With this in view, he experimented on *Amblycorypha rotundifolia brachyptera*. The synchronism exhibited by ten males was almost perfect. After observing the song

of the whole group for two nights, the experimenter removed four of them to another cage after first removing from each the front tibiae containing the tympanal organs. Thereafter the synchronization in this group was completely ruined, while it continued as before in the cage of controls.

Fulton then got still more remarkable results on the Nebraska conehead, *Neconocephalus nebrascensis*. Separating four males into two lots, and kept out of hearing range of each other, it was found that the synchronism of each couple was perfect. The front tibiae of one pair was then removed. On the second evening after the operation these two coneheads were singing with a conspicuous lack of coordination; at the same time the normal coneheads in the other cage were keeping up perfect synchronism.

Crickets

In spite of the fact that Lutz (1924) takes the conservative view of the auditory powers in insects, he states (p. 356) that while breeding crickets for other purposes he had hundreds of them under constant observation, and "it seemed to me that I could tell by listening to the males whether they were courting females, defying other males, or just passing the time." Inasmuch as he is not the one for whose edification the performance was done, won't he please give the crickets credit for doing at least as well as he did?

Lubbock (1888, p. 63), mentions that Brunelli kept and fed several male crickets, *Gryllus viridissimus*, in a closet, and they continued singing all day, but a rap on the door would stop them instantly. By practice he learned to imitate their chirping; when he did this at the door, at first a few would answer him in a low note, and then the whole party would take up the tune and sing with all their might.

That the tympanal organs in field crickets are auditory in function is supported by the ingenious and controlled experiments of Baier (1930). Crickets previously conditioned to life in cages were placed, with sexes segregated, in different rooms sufficiently distant to be beyond the range of sound perception. A microphone, placed in the cage of males, was connected by telephone with a receiver in a cage of females of the same species. The females approached the receiver with actively moving antennae and performed movements indicative of search for partners. When the current was interrupted, they moved away from the receiver, but as soon as the connection was re-established they came to the receiver again. The females whose tympanal organs had been excised failed to respond, as did also those which had been locally anaesthetized with ethyl-chloride. Phonograph records of the male stridulatory notes produced the same response as the living insects.

Regen (1912), by controlled experiments and the use of phonograph records, got some important results with field crickets, *Liogryllus campestris*. Females responded to the song of the male on the phonograph, and ceased to respond when the tympanal organs were removed. He proves conclusively that the sound, and not odor or sight, attracts and directs the female toward the male. He further tested the auditory ability of the females by placing on the floor two glass vessels, one lined with black paper and the other transparent. Into the opaque jar he placed a chirping male, and into the transparent jar a quiet one. Normal females ran to the vessel containing the invisible, chirping male, but ignored the other one with its male in clear view. Females whose tympanal organs on the forelegs had been deleted did not react

to either vessel. That the response was not due to an odor liberated by the movement of the male's wings when chirping was shown by removing the edges of the wings, so the motion, while otherwise unchanged, was noiseless; the response of the females ceased.

Regen (1926) carried on experiments to test the influence of artificial sounds on the stridulation of the cricket, *Thamnotrixon apterus*. He finds that a Galton whistle, a bell, etc., and the chirping of other species interfered with the chirping of this cricket, and that the "S" sounds of the human voice called forth their response. Tests were also made to determine the highest pitch to which they would respond.

Baumgartner (1911) says the female mole-cricket, *Gryllotalpa borealis*, has a loud, distinct chirp in the burrow. It usually consists of a single note, but it may be repeated at short intervals. The note is less shrill than the ordinary call of the male. Both sexes use their calls as a means of recognition in the dark burrows, and especially when digging new tunnels.

Weaver and Bray (1933) experimented on auditory nerve impulses in crickets and grasshoppers. This consisted in picking up electrical changes produced in the tissues as a result of sound stimuli, amplifying these changes and conducting them to a telephone receiver where they were observed as sound. Responses were observed in katydids ranging from 800 cycles per second to well above the limit of human hearing; in crickets, from 300 to 8000 cycles. The response was a slushing noise, and was the same in quality regardless of the frequency of the stimulus.

Tree Crickets

Shull is quoted by Allard (1930) as having observed two snowy tree crickets,

about five feet apart, chirping in such accurate unison that he did not at once realize that there were two of them. Soon one stopped; the other hesitated, chirped weakly and even lost a beat. After an irregular solo of several minutes, the other cricket resumed. At the first chirp, the first singer struck a note out of tune, then lost a beat as if startled; it next voiced a half-dozen weak, uncertain chirps, then increased in intensity until the two crickets were again chirping in exact unison. Allard remarks that this behavior would imply that the crickets not only hear their own sounds, but also were attempting to preserve a unison in them.

Allard (1929, p. 583), says from his own observations that many insects not only chirp in small groups, but a number of them appear inclined to bring their notes into synchronism with those of their fellows. "This procedure seems somewhat remarkable, and some . . . have been inclined to question this behavior. Synchronous chirping is an undoubted fact, however, and there is no reason why an insect or bird should not in some instances perceive rhythm and keep step as well as a human being." He is convinced that the snowy tree-cricket and also the little tree-cricket, *Cyrtoxipha gundlachi*, prefer to chirp in unison with their fellows. By an imitation of their noises he has led chirping crickets to speed up their rate noticeably in order to keep pace with him.

Allard (1911) describes the stridulation of the shield-backed grasshopper, *Atlantius pachydermus*, and says that several times while watching them by lantern light he lisped an imitation of the notes and got an immediate response.

Fulton (1925, 1928 a, 1928 b) has shown in important experiments that tree crickets, *Oecanthus niveus*, actually hear sounds,

and do so with the tympanal structures on the fore tibiae. In control experiments, they were found to chirp in unison "as if a single cricket were singing." In another lot with the forelegs amputated, the chirping was quite different, without any rhythmic unison whatever, producing "an utter confusion of notes."

Fulton (1933) gives the views of some other investigators as well as his own on the sound making habits of certain female Tettigoniidae. The female call is made in direct response to that of the male; this of course indicates that the female must have heard the sounds. He quotes Riley (1874) who describes the song of *Scudderia furcata*, and says "the call is occasionally responded to by a faint chirp of the females produced by stretching out their wings as if for flight." He says the prolonged, rattling song of *Microcentrum rhombifolium* is "invariably answered by a sharp chirp or tschick from one or more females who produce the sound by a sudden upward jerking of the wings."

Fulton himself observed *Scudderia texensis*. He heard a male singing in the yard one night, and immediately after it sang, a brief series of faint, tapping sounds came from a cedar tree. With a flash-light he located the female and saw it produce the sound by working the tegmina in a manner similar to the male. Her reply always came about a half-second after the conclusion of the male's song. On another night he heard, at a distance of about thirty feet, a faint sound like "chp" following the prolonged ticking song of *M. rhombifolium*; this was repeated almost every time a male sang within a radius of forty yards. He located the female and watched her make the noise by spreading and closing the dorsal edges of the tegmina. He actually found that the males come to the females for mating. "The

females did not move from the places where they were first discovered. If the males are guided only by the faint replies made to their songs, they must have a remarkable ability to locate sounds."

Insects often make sounds, says Allard (1929) for the same reason that birds and humans sing, "because they love sound and find it a means for self-expression; it is a part of their lives." Song may in some instances have a sexual significance, but the theory ascribing sound to sex in insects has probably been much overdone.

I have heard the snowy tree-cricket chirp at the rate of about 90 times per minute all night long. Think what this means; 5400 chirps per hour, 64,800 chirps in a 12-hour night, nearly 4,000,000 chirps in a period of 60 days, demanding the muscular energy of 16,000,000 wing strokes on the basis of four strokes for each chirp. What is it all about? Sex alone does not explain it; no cricket needs to chirp itself to death—chirp a cool million or five million times day and night in one bush to win the momentary attentions and embraces of a silent, lonely female in the vicinity.

Cockroaches

Because roaches do not make sounds that human ears can hear, and because students have been unable to detect organs of hearing in their bodies, roaches have generally been regarded as dumb.

Miall and Denny (1886), in their authoritative book on the roach, conclude that "the auditory organs are best developed in such insects that produce sound as a call to each other. The cockroach [*Blatta orientalis*] is dumb, and it is therefore not a matter of surprise that no structure which can be considered auditory should have been detected in this insect." The attitude of these authors in the matter of sound perception has set the standard, and students generally accept this opinion. Clarence L. Turner (1916) reflects this attitude when he says "the sense of hearing is obviously not a factor in the sexual

activities in the roach, for there are no organs for the reception of sound." Charles H. Turner (1913), however, records on the contrary that while doing other experiments with this roach he noticed that "when the tinnerns were fixing some guttering of a near-by house, the roaches were quite responsive to certain noises made by the tin." A meager observation by Graber (1882) mentions that a *Blatta*, running about on the floor, would stop for an instant when the strings of a violin were struck, or in another case, a blinded specimen hung by a thread became violently agitated at a sudden tone from a violin.

Some interesting work has been done in a highly technical way by Pumphrey and Rawdon-Smith (1936 a). With the use of platinum electrodes brought in contact with an active nerve, the authors show that "a response from certain tactile receptors may readily be excited by auditory stimuli." Evidence is produced to show that the anal cercus of the cricket and the cockroach, *Periplaneta americana*, has a partly auditory function. On the other hand, so they say, it seems possible that the acoustic function of the cerci is merely incidental. While the difficulty of distinguishing between acoustic and vibratory stimuli for an organ such as the cercus is fully realized, the relative insensitivity of the organ to all but the lowest frequencies, together with the fact that in the cricket it is frequently in contact with the ground, leads us to suppose that its main function here is to mediate the detection of earth-borne vibrations. In the cockroach where the cercus is carried more or less erect, it seems likely that its function as a wind gauge may be equal in importance to its function as an acoustic organ. (See also same authors, 1936 b and 1936 c.)

EXPERIMENTAL EVIDENCE

The oriental cockroach, Blatta orientalis

The life histories of the three common species of cockroaches, *Blatta orientalis*, *Periplaneta americana* and *Paracoblatta pennsylvanicus*, were studied during 1937 and 1938. (The identifications of the latter two species were kindly verified by Mr. Morgan Hebard of the Academy of Natural Sciences of Philadelphia.) These roaches were confined for the most part in large glass fish bowls. Close observation during that period has given me no indication that roaches can create sounds audible to the human ear. On the other hand, the evidence from several incidents has led me to believe that they may be able to hear certain sounds. While searching for tangible proof of this, I often sat gazing into the bowls containing many roaches. On one such occasion, during an approaching storm, the wind banged the door, and what I saw then induced me to plan experiments to test their auditory powers.

The roaches often rested on a pyramid of cardboard which occupied the center in each glass container. When the door banged, a panic occurred among half of those that were resting quietly on the pyramid before me; the remaining half-dozen did not move. This raised in my mind these questions: Did the roaches actually hear the sound, or did the vibration of the bang cause the table or the container to shake and induce them to react through the sense of touch? If one or the other, why did some scuttle to safety and others remain quiet? The table on which the bowl rested was near the door; did some of them see the movement of the door and react through the sense of sight? Both the vibrations of the table and the sight of the moving object

were factors which may have influenced their behavior, so I decided that in further experiments these two probable influences must be excluded.

To this end, a screen was placed between the container and the door, so the roaches could not possibly see its motion. Precautions were also taken to prevent any vibrations other than sound-waves from reaching them; this was done by placing large pads of cotton wadding under each table leg, under the fish-globe which rested on the table, and under the glass lid that covered the globe. The latter method left open spaces between the props of cotton through which sound could enter, and the cotton prevented the lid from noisily vibrating against the glass. Experiments were then carried on by purposely banging the door from time to time (Series A), until the banging of the door caused a large portion of the plaster ceiling to crash to the floor. After this cataclysm, methods of a more scientific nature were followed (Series B). The early experiments (Series A) were, however, very valuable, for they suggested the plan for the later work.

Experiments: Series A

Exp. 1. June 23, 1937. Door banged and four of the six roaches in the jar gave a sudden start; two of these ran to the floor. Two of them gave no response.

Exp. 2. August 25, 1937. 9:30 p.m., 86° F. Three females on pyramid; door was banged; one gave a quick jerk, two did not move.

Exp. 3. August 27, 1937. 8:00 a.m., 80° F. Three roaches, one female and two males, were on top of pyramid; banged the door five times at intervals of one-half minute. First bang brought no reaction; second bang brought a slight movement of the female only; third bang

brought a marked jerk from the female; fourth bang saw the female run down the incline for an inch and stop suddenly, while the two males reacted for the first time, giving a quick jerk; one moved no further, and the other ran for a distance of an inch and stopped; at the fifth bang the female ran to the floor and hid under a cardboard, while the two males ran down the incline for a short distance and stopped.

Exp. 4. One half-hour later. Two males and one female same as in last experiment; these and one new male were resting on pyramid. First bang, the two old males and one old female dropped to the floor and ran under cover; the new male refused to move and was now the only one exposed to view during the subsequent four bangs; this male remained adamant and refused to budge during the entire process.

Exp. 5. August 27, 9 p.m., 82° F. Two females on cardboard pyramid. With the first bang, both ran a short distance and stopped.

Exp. 6. August 27, 9:40 p.m., 82° F. One female and one male on pyramid. Five door-bangs at one-fourth minute intervals. The female reacted to all five bangs, very strenuously to the first two, feebly to the next two, and merely a slight jerk at the last; the male reacted to only one, the third, and this with a jerk.

Exp. 7. August 27, 9:50 p.m. 82° F. Only one female exposed; five bangs given at intervals of one-fourth minute. With the first, she rushed down the incline for two inches and stopped; at the second she ran to the other side of the pyramid and stopped; to the last three she gave no further reaction.

Exp. 8. September 1, 8:30 p.m., 90° F. Nymph in the last instar. Five bangs at intervals of one-fourth minute. With the

first, it ran three inches and stopped; at second and third, it ran further; at the fourth and fifth, there was no response.

Exp. 9. Last test repeated five minutes later. With first bang the nymph gave a sudden jerk; it gave no reaction whatever to the other four.

Experiments: Series B

In the preliminary experiments we have evidence that roaches possess the ability to perceive sounds and that they react to them by a jerk or a short run. On the other hand, some individuals give no reaction whatever to loud sounds; this may signify one of two things: either certain ones are deaf to these sounds, or all hear them but certain individuals inhibit any outward response.

In the present series of experiments, I intend to test their reaction to some sharp sound similar to that of the door-banging, and, in addition to this, to test their reaction to sound-waves of various known vibrations. For producing a sharp sound, a galvanized wash-tub was banged with a small fireplace shovel. For the planning and setting up of an instrument for producing sound of a known number of vibrations per second, I am indebted to my son David, who installed a device for producing sounds varying from a frequency of 25 vibrations per second upwards to one of 6000 vibrations. He describes the instrument as follows:

The sound impulses were generated by an audio-oscillator with a continuous frequency range of 25 to about 6000 vibrations per second. The circuit employed was the conventional one using a neon glow lamp in connection with fixed condensers and a more variable resistance. This circuit gives a saw-tooth wave form instead of the more usual sine wave form. These sound impulses were amplified by a four watt audio amplifier, and reproduced through a dynamic loud speaker. The loud speaker was suspended by springs from the ceiling in order to eliminate the possibility of vibrations reaching the

roaches through the table, or through any other medium than through the air. While this source of audio power left much to be desired from the standpoint of the physicist working in sound, due to the non-sinusoidal character of the wave-form, and due to the fact that a slight amount of 60 cycle hum was introduced into the output from the power lines, it was considered perfectly adequate for the work in hand.

A platform at a lower level than the loud speaker, and two feet away, was set up on the table. A jeweler's tray, with a velvet floor which would give the roach a foothold, was placed on the platform, and finally the arena was made by placing a tin ring, five inches in diameter and four inches high, on the velvet-covered tray. A thick padding of cotton and felt was placed beneath the tray, beneath the platform and also under each leg of the table, to prevent vibrations other than aerial sound-waves from reaching the roaches. The stock of roaches, each numbered and placed in a separate small jar, was kept in a room at the extreme opposite end of the house where, behind closed doors, they could not hear (and therefore could not be influenced by) what was going on in the laboratory. They were carried into the laboratory one at a time and dropped into the arena where the tests were given. The earlier tests were made at intervals of ten seconds, but later at intervals of one-half minute.

The results with the audio-oscillator during the early part of the work were principally negative, and I decided to introduce the loud, sudden sound. By hanging the inverted wash-tub over the back of a chair and striking it with the shovel, I was able to create a bang equal to, if not louder than, the banging of the door. The tub-banging experiments were alternated with those of the audio-oscillator. Sheets were especially ruled and symbols were employed so that the results of each test could be quickly recorded.

The method was, therefore, to drop a roach in the arena where it would run around for a few seconds and then stop; immediately after it had quieted down a sound was given, and the roach either remained motionless or responded by running again or by giving a startled jerk.

Experiments on adult females

The work was carried on with 23 females, each kept in a separate container and each given several trials on many separate days. As tests were made, the

complete and pronounced reaction; an X indicates a slight reaction; a minus sign indicates no reaction whatever. In order to simplify the results, I have omitted in the tables of summary (Tables 2, 4 and 6) the distinctions of slight and pronounced reactions, and have treated both reactions as one. In the combined trials 1 and 2, for example, we read that female No. 16 gave 15 responsive reactions to 15 bangs on the tub, at intervals of ten seconds. In Trial 4 we read that 7 negative results, 2 strongly positive reac-

TABLE 1

*Sample of recording sheets used in testing hearing ability of individual cockroaches**

No. 16. Species: *B. orientalis*. Sex: Female adult

TRIALS	DATE 1937	TIME		AGE	STIMULUS	VIBRATIONS PER SECOND	TEMP.	TESTS										REMARKS
		A.M.	P.M.					1	2	3	4	5	6	7	8	9	10	
1	9/26		3:30	Young	T.B.		60	*	*	*	*	*						Tests given at intervals of 10 seconds
2	—		3:35		T.B.		60	*	*	*	*	*	*	*	*	*	*	
3	10/3	9:55				6000	70	—	—	*	*	*						
4	—	10:00			T.B.		70	—	—	*	*	*	×	—	—	—	—	All sound impulses given for period of 10 seconds
5	—	10:15			T.B.		70	*	*	×	*	*	*	*	*	*	*	
6	10/6		9:00			6000	70	*	*	—	—	—	—	—	—	—	—	
7	—		9:05			6000	70	—	—	—	×	×	×	—	×	—	—	
8	—		9:12		T.B.		70	—	—	—	×	×	×	—	—	—	*	
9	—		9:18			500	70	—	—	—	—	—	—	—	—	—	—	
10	10/9		1:40			6000	68	—	—	—	—	—	—	—	—	—	—	
11	—		1:43			6000	68	—	—	—	—	—	—	—	—	—	—	
12	—		1:47		T.B.		68	—	—	*	*	*	*	—	*	*	*	
13	—		1:53		T.B.		68	—	*	*	*	*	*	—	—	—	—	

* T.B., tub-bang; —, no reaction; X, slight reaction; *, very definite reaction.

results were recorded on specially ruled sheets, a sample of which is given in Table 1.

This table is self-explanatory. Each trial (first column) consisted of either five or ten tests (last series of columns). The abbreviation "T.B." under stimulus means tub-banging, and the number under "vibrations per second" is that used for experiments with the audio-oscillator. The symbols given in columns 1 to 10 under the heading "Tests" needs an explanatory remark: the asterisk indicates a

tions and 1 slight reaction were the behaviors of the roach. Again in Trial 6, when subjected to impulses of 6000 vibrations per second, and continued through Trial 7, the responses were poor. The results of the work on all 23 females are tabulated in Table 2.

This table shows that, at temperatures varying between 54° and 80° F., the 23 females were given 44 trials involving 370 tests with a loud, metallic bang. The results, tabulated in columns 6 and 7, show 122 negative and 248 positive re-

TABLE 2.

Tabulation of results of hearing tests made on 23 adult female *B. orientalis cockroaches*

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	REMARKS
♀ NO.	DATE 1937-1838	TEMP. F.	TUB BANG				1000 VIBRATIONS				6000 VIBRATIONS				
			No. Trials	No. Tests	Negative	Positive	No. Trials	No. Tests	Negative	Positive	No. Trials	No. Tests	Negative	Positive	
2	9/10	74	—	—	—	—	—	—	—	—	1	5	2	3	
3	9/10, 9/12	70-74	—	—	—	—	—	—	—	—	2	10	8	2	
5	9/26	54	1	10	8	2	—	—	—	—	—	—	—	—	
7	9/28, 9/29, 9/30	58-70	3	25	13	12	1	5	5	0	1	5	5	0	
12	10/5	80	2	20	8	12	—	—	—	—	4	30	30	0	
13	10/6	68	1	5	1	4	1	10	10	0	2	10	10	0	
16	9/26-10/9	60-70	7	60	18	42	—	—	—	—	5	35	29	6	
21	10/7	62	1	5	0	5	—	—	—	—	1	5	5	0	
23	10/9	66	2	15	14	1	—	—	—	—	2	10	10	0	Nearly dead; has only 5 legs
24	9/8	72	—	—	—	—	—	—	—	—	1	5	4	1	
32	9/26	62	3	25	15	10	—	—	—	—	—	—	—	—	Very old; died next day
34	9/22-10/3	64-80	6	60	8	52	1	5	5	0	2	10	10	0	Antennae off
"	10/3	70	1	10	2	8	—	—	—	—	—	—	—	—	
44	9/24	70-76	4	35	4	31	—	—	—	—	1	5	5	0	
66	4/30	68	1	10	3	7	—	—	—	—	2	20	20	0	
67	4/28-5/28	62-80	1	10	1	9	—	—	—	—	5	40	40	0	
68	4/36	64	1	10	4	6	—	—	—	—	2	20	20	0	
70	5/22	70	2	10	3	7	—	—	—	—	3	15	15	0	
74	5/3 -5/30	72-80	1	5	1	4	—	—	—	—	4	35	14	21	
100	5/29	72	2	10	8	2	—	—	—	—	1	5	5	0	
101	5/29	78	1	10	3	7	—	—	—	—	1	10	10	0	
105	6/1	80	1	10	4	6	—	—	—	—	1	10	4	6	
106	6/1	80	2	15	3	12	—	—	—	—	1	5	5	0	
109	6/1	74	1	10	1	9	—	—	—	—	1	10	9	1	
Total			44	370	122	248	3	20	20	0	43	300	260	40	
Per cent						67%								13.3%	

sults; in other words, 67 per cent of the tests indicate that adult females heard and responded to the loud, sudden noise. The audio-oscillator tests (columns 8 to 11) at 2000 vibrations per second gave no positive reactions whatever; at 6000 vibrations per second (columns 12 to 15), 40 out of 300 tests (or 13.3 per cent) gave positive results. This percentage is so small that one would be tempted to disregard these results entirely, except for

tion she reacted in 8 out of 10 tests. This indicates at least that the antennae are not the seat of hearing. One might suspect that negative results are due to fatigue from excessive testing, but a careful check shows this is not true. Insects, of both sexes and also nymphs, which gave negative results in the vibration tests often responded to the louder test immediately afterward, as may be seen, for example, in Table 1.

TABLE 3
Sample of record made by a nymph ($\frac{1}{2}$ grown) in hearing-ability tests
No. 4. Nymph $\frac{1}{2}$ grown. Species: *B. orientalis*

TRIALS	DATE	TIME		AGE	STIMULUS	VIBRATIONS PER SECOND	TEMP.	TESTS										REMARKS
		A.M.	P.M.					1	2	3	4	5	6	7	8	9	10	
1	9/24		10:07	$\frac{1}{2}$ grown	T.B.		70	*	*	*	*	*	*	*	*	*	*	
2	—		10:17		T.B.		70	*	*	*	*	*	*	*	*	*	*	
3	9/26		12:10		T.B.		60	*	*	*	*	*						
4	—		12:15			6000	60	—	—	—	—	—						
5	—		12:20		T.B.		60	*	*	*	*	*						
6	—		12:35		T.B.		61	*	*	*	*	*						
7	10/3		2:00		T.B.		70	*	—	*	*	*	—	—	*	*	×	
8	—		2:08		T.B.		70	—	×	—	×	*	×	×	×	×	*	Antennae cut off. Continuation of trial 8
9	—		2:10		T.B.		70	*	×	*	*	*	*	*	*	*	*	
10	10/6		8:00			6000	70	—	—	—	—	—						
11	—		8:05			6000	70	—	—	—	—	—						

the fact that the 40 good responses came from only 7 females. This indicates either that certain females have a more acute sense of hearing than others, or that, because of old age or other causes, they are less able to inhibit reaction to sound waves of 6000 vibrations. Female 74 gave a good account of herself, having responded to 6000 cycles in 21 out of 35 tests; female 16 responded equally well in both banging and vibration tests, while female 105 responded in 6 out of 10 tests at 6000 vibrations. One individual deserves special mention: female 34 went through the last ten tests with her antennae removed at their base; in this condi-

Experiments on nymphs

The same method of experiment and the same tabulations were made for the nymphs as for the adult females. These immature roaches were $\frac{1}{2}$ to $\frac{3}{4}$ grown.

In Table 3 I present a sample record for one nymph (No. 4). This is to be read in the same way as the previous one on the adult female. It shows that this roach gave a good many positive responses to the sound produced by banging the tub. In Trials 1, 2, 3, 5, 6, out of 35 tests only 5 were negative; and for the ones tested with 6000 vibrations per second (Trials 4, 10 and 11) all were negative. In Trials 8 and 9, I find that the loss of antennae is

TABLE 4

*Sound recordings of hearing tests on 17 nymphs**Nymphs $\frac{2}{3}$ to $\frac{1}{2}$ grown*

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
NYMPH NO.	DATE 1937-1938	TEMPERATURE F.	TUB BANG				500 VIBRATIONS				2000 VIBRATIONS				6000 VIBRATIONS				REMARKS
			No. Trials	No. Tests	Negative	Positive	No. Trials	No. Tests	Negative	Positive	No. Trials	No. Tests	Negative	Positive	No. Trials	No. Tests	Negative	Positive	
4	9/24-10/6 10/3	60-70 70	6	45	8	37	—	—	—	—	—	—	—	—	3	10	10	0	Antennae off
6	9/28-10/3	62-70	6	60	22	38	1	5	5	0	—	—	—	—	3	15	15	0	
9	9/29, 10/9	60-68	3	30	7	23	—	—	—	—	1	5	5	0	3	15	15	0	Had only 1½ antennae
11	10/ 4, 10/6	66-70	2	10	0	10	1	5	5	0	—	—	—	—	3	20	20	0	
13	9/23	78	1	10	0	10	—	—	—	—	—	—	—	—	2	10	10	0	
14	10/6	70	—	—	—	—	—	—	—	—	—	—	—	—	2	10	10	0	
20	10/ 6, 10/9	66-68	2	15	7	8	1	10	10	0	1	5	5	0	3	25	25	0	
22	10/9	62-64	1	10	2	8	2	10	10	0	—	—	—	—	4	20	20	0	
25	10/19	60	3	25	4	21	1	5	5	0	—	—	—	—	3	20	20	0	
43	10/3	66	2	20	4	16	—	—	—	—	—	—	—	—	2	10	10	0	
44	10/7	60-62	2	10	1	9	1	5	5	0	—	—	—	—	6	30	30	0	
45	4/21- 5/23	62-82	3	25	11	14	—	—	—	—	—	—	—	—	5	35	35	0	
79	5/3 - 5/26	72-78	4	40	23	17	—	—	—	—	—	—	—	—	4	25	25	0	
81	5/31	72	2	20	4	16	—	—	—	—	—	—	—	—	1	5	5	0	
84	5/30	82	3	25	11	14	—	—	—	—	—	—	—	—	2	20	20	0	
95	5/26	72	3	25	11	14	—	—	—	—	—	—	—	—	2	20	20	0	
98	5/3	82	1	10	7	3	—	—	—	—	—	—	—	—	1	10	10	0	
Total.....			46	400	127	273	7	40	40	0	2	10	10	0	49	300	300	0	
Per cent.....						68.2%													

no hindrance to perception of the loud sound.

Seventeen nymphs were tabulated in this

way, and the results of the work are presented in Table 4.

Here again we see that the responses to

the audio-oscillator at various frequencies was nil, but the 400 tests using the loud bang as a stimulus, 68 per cent gave positive responses. Here too, as in the experiments on adult females, we find that the removal of the antennae is no hindrance to the perception of this sound.

I have thus far been unable to distinguish the sexes in nymph roaches, and it might be possible that in the immature

method of approach. I refer to Trial 9; here the male was permitted quietly to spend two days, without tests, in the arena on the experimental platform after having given negative results in the 6000-vibration test in Trial 8. On the morning of October 5 I watched this roach for half an hour and found that, to the best of my knowledge, it was asleep. I then suddenly gave the 6000-vibration sound and,

TABLE 5
Sample of record made by an adult male cockroach (No. 24) in hearing tests
No. 24. Species *B. orientalis*. Sex: Male adult

TRIALS	DATE	TIME		AGE	STIMULUS	VIBRATIONS PER SEC-OND	TEMP.	TESTS										REMARKS
		A.M.	P.M.					1	2	3	4	5	6	7	8	9	10	
1	10/1		10:30	Very old	T.B.		72		×									Continuation of Trial 2
2	—		10:35		T.B.		72	×	*	*	*	*	*	*				
3	—		10:40		T.B.		72	*	×			*	*		*	*	*	
4	—		10:45			6000	72	*	*	*	*	*			*			
5	—		10:52			6000	72	×			*	*						
6	10/3		10:30	T.B.		6000	68											Asleep before test 1
7	—		10:45				68	*			×	×		*	*	*	*	
8	—		10:45			6000	68											
9	10/5	8:30				6000	70	*										
10	—	8:35		T.B.		6000	70					*						
11	—	8:42					70			×			*					
12	—	8:47				6000	70											
13	—	9:00				6000	70	×	*	*		×	*	*			×	
14	—	9:07				1000	70				×	×						
15	—	9:15				1000	70	*	*									Died Oct. 7/38
16	10/5		8:00			6000	78											
17	10/5		8:05			6000	78	*										
18																		

stages one sex is more keen than the other in sound perception.

Experiments on adult males

The conditions and methods of the experiments were the same for the males as for the nymphs and females. The work was carried on with 21 males.

Table 5 gives a sample record of one male, No. 24. There is one reaction which is especially noteworthy, in that it brings into work of this kind a new

to my great surprise, the roach gave a sudden leap. Had the insect been awake, it would undoubtedly have inhibited the response, as it did in the tests of Trial 8 and also in tests 2, 3, 4 and 5 of Trial 9. The success of this venture caused me to repeat the "sleep" experiment with male No. 58 (see Table 6), with the same result. Taken unaware, at the sound of 6000 vibrations he also gave a sudden leap, a reaction which he never repeated in the twenty-four tests which followed. A

TABLE 6

Tabulation of results of hearing tests on 21 adult male cochranes, *B. orientalis*

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	REMARKS
♂ NO.	DATE 1937-1938	TEM- PERA- TURE F.	TUB BANG				1000 VIBRATIONS				6000 VIBRATIONS				
			No. Trials	No. Tests	Negative	Positive	No. Trials	No. Tests	Negative	Positive	No. Trials	No. Tests	Negative	Positive	
24	10/1- 10/5	68-78	5	45	21	24	2	10	6	4	10	65	46	19	Very old, died 2 days later
44	9/26	62	1	10	5	5									
50	4/20- 4/26	58-84	8	55	26	29	1	5	5	0	7	60	60	0	
51	4/21- 5/30	64-84	3	25	8	17	—	—	—	—	4	40	40	0	
52	4/ 4- 5/30	74-80	3	20	6	14	—	—	—	—	3	30	28	2	
54	4/21- 5/30	66-80	4	25	10	15	—	—	—	—	8	75	69	6	
57	4/25- 5/29	64-80	3	20	10	10	—	—	—	—	3	15	15	0	
58	5/27	74	4	25	13	12	—	—	—	—	4	25	24	1	Responded to 6000 when asleep
61	4/27	72	1	10	4	6	—	—	—	—	2	15	15	0	
62	4/27- 5/23	64-78	2	20	6	14	—	—	—	—	3	30	30	0	
63	4/27	78	1	5	2	3	—	—	—	—	2	20	20	0	
64	4/27- 5/23	72-64	3	25	19	6	—	—	—	—	4	35	35	0	
71	4/29- 5/22	70-72	2	15	11	4	—	—	—	—	2	20	19	1	
73	5/3- 5/30	80-84	2	10	7	3	—	—	—	—	3	15	15	0	
74	4/27	76	2	15	13	2	—	—	—	—	2	15	15	0	
75	5/1- 5/22	62-72	2	15	12	3	—	—	—	—	2	10	10	0	
76	5/1- 5/30	72-82	2	20	15	5	—	—	—	—	3	25	25	0	
77	5/1- 5/30	72-80	2	20	8	12	—	—	—	—	3	25	22	3	
99	5/29	78	1	10	1	9	—	—	—	—	1	10	10	0	
103	6/1	80	1	10	1	9	—	—	—	—	1	5	5	0	
107	6/1	78	1	5	0	5	—	—	—	—	1	5	5	0	
Total.....			53	405	198	207	3	15	11	4	68	540	508	32	
Per cent.....						51.2%				26.7%				5.9%	

new point of technique in experimental projects in hearing is brought out in this case; it is, as I said before, to catch them unaware during their sleep, and get reactions before they have time to consider how they should behave. The results of the work on all 21 males are presented in Table 6.

In this table we find the work on twenty-one males was carried on between September 26 and June 1, at temperatures that varied from 58 to 84° F. They responded to the loud bang in 207 out of 405 tests, or 51 per cent. In fifteen tests of 1000 vibrations given to two males, only one responded, and it did so in four out of ten tests. In the last four columns we have the details of male roach reaction to 6000 vibrations per second; in 540 tests we got only 32, or 5.9 per cent, positive responses. This result is so low that one is at first tempted to discard it entirely and conclude that male roaches do not hear vibrations of this intensity. When one examines the reactions of individual roaches, however, one must conclude that the males hear these vibrations but are masters at inhibiting any outward show of their having received these sound-waves. This conclusion is reinforced by what I have recorded for their behavior when 6000 vibrations were given to them when asleep and will also be further strengthened (for other sounds) in what I have to say under the heading of Series C. Referring again to individual reactions with this number of vibrations (last column) it is well to note that we got from one male three positive reactions out of twenty-five tests, in another, six out of seventy-five, in yet another, two out of thirty, and finally in two instances, one each out of twenty and twenty-five tests. The crowning glory, however, is male 24, who reacted to both 1000 and 6000 vibrations; in the former tests he

gave four positive reactions out of 10, and in the latter, 19 out of 65.

This demonstrates quite clearly that at least one male reacted sufficiently well to prove that 6000 vibrations are heard. But why should one male give such good results in contrast to the negative or very poor positive results of the others? The reason is not difficult to find. The length of life of adults in this species is short, but that of the male is considerably shorter than that of the female. By the middle of September the males have practically all died off, and only rarely is one to be found. One such male had outlived his "three-score and ten", and was used in the experiments from October 1 to 5, and was known as No. 24. This male was therefore very, very old, and died two days after the conclusion of the experiments. He was, in fact, the sole survivor of his sex for the season. It seems incredible at first that one so old should still possess such an acute power of hearing. But the indications are that this male No. 24 responded so readily to sound waves because of and not in spite of its old age. Additional work on this problem will perhaps show that young males are much more successful in inhibiting reaction to sound than old ones are. Males in the state of old age and senescence, it seems, are unable to inhibit their reactions so successfully as do the younger males.

Additional observations on Blatta orientalis

An accidental observation led Dr. C. H. Turner (1913) to suspect that the oriental roach may be able to perceive sound, for he says, "One day when some tinnerns were fixing the guttering of a near-by house, the roaches were quite responsive to certain noises made by the tin." On the night of May 31, 1938, some excavating was being done about a half-mile from my home. I was watching a large glass cage

of roaches when a blast of dynamite was discharged; this noise caused a panic among almost all of the eighteen roaches, practically all of them scampering for cover. A similar reaction was witnessed a few weeks later when a peal of thunder sent most of the inmates of the cage quickly to shelter.

Experiments: Series C

Blatta orientalis, *Periplaneta americana*, and
Paracoblatta pennsylvanica

Banging of doors, beating of tubs, peals of thunder, notes from a violin and hammering of tin gutters all bring forth a definite response from roaches, showing beyond the shadow of a doubt that they perceive soundwaves through the air. Since they apparently give forth no sound for the purpose of attracting mates, it is quite evident that this sound perception is for the purpose of hearing approaching enemies and fleeing from them. That being the case, why do we not get one hundred per cent positive reaction in all of the experiments? The only logical answer to this question is that roaches do hear sounds but inhibit outward responses. We know this to be so, because in those instances when we came upon them unawares during time of sleep, we got favorable reactions even under the most difficult tests, i.e., with sounds of 6000 vibrations.

Nature has apparently endowed the roach with the ability to hear dangerous sounds, so that it can escape to safety. She has also endowed them with mental machinery which causes them to remain stark still and inhibit any movement in the face of danger. This is seemingly a paradox. Evidently there is an Ethiopian in the woodpile somewhere, and I think I have ferreted him out. All of the experimental work with roaches was done in broad daylight, or, when it was done

at night, it was carried on with the aid of a 50-watt electric bulb glowing directly over the experimental platform. Daylight or artificial light was necessary in order to observe the slightest movement of each roach. But one must not forget that roaches are insects of nocturnal habits and in all of the work they were subjected to experiments at hours that were unusual and unnatural to their normal period of activity. Perhaps the inhibition of response was due to this unusual condition. Some such protective adjustment is what would be expected from a nocturnal insect during the daylight hours when they normally should be within their dark crevices. It would be suicide for them to rush from their places of safety during daylight hours at the sound of danger, but in the darkness of night, when they fare forth on food-hunting expeditions, a sharp sound should cause them to retreat quickly to the crevices they had left. If sound experiments could be carried on in darkness, would the roaches likewise inhibit movement? Darkness is not conducive to good observation; but a method was worked out whereby the roaches could be tested in almost complete darkness.

Blatta orientalis

To this end, I set up the following device. Into a large, heavy plateglass aquarium (32 x 16 x 12 inches), I placed at one end several clay flower-pots, to provide hiding places for the roaches; at the opposite end I placed a low platform containing food. During the daytime the roaches hid themselves among the pots, but during the dark and quiet night they made their way to the opposite end for food.

After permitting them to become accustomed to their surroundings for about two weeks, I tested them on three suc-

cessive nights to see if the flashlight, dimmed by a covering of two layers of thin cloth, would cause them to run to their hiding places. I had previously learned that by switching the electric light on at night, I could get them to abandon food and courtship and run for cover. Now I wished to discover if rays from a dim flashlight, shedding just enough light for me to see what was going on, would be sufficiently low not to alarm them. I found, to my complete satisfaction, that they were not influenced by this very dim light, and that I could creep up to the cage and let the dim rays fall upon its floor without disturbing the many insects there occupied with courtship, eating or resting.

After becoming satisfied that there was no reaction to dim light, I began my "thumb-nail" experiments. This was carried on by snapping the thumb-nail against the wall of the glass container, thereby creating a sharp sound. This caused a very definite reaction from all the roaches. Whatever their position or condition at the time, they turned about and made for the direction of their hiding places. After a few seconds I repeated the snap with the nail against the glass, and this caused another forward movement with most of the population rushing for cover; by the time I had completed the third snap, all of the roaches had completely disappeared. It is interesting to note that the sound of my finger nail against the glass did not cause the roaches to move about in panicky manner, but they appeared to remember their hiding places, headed stright for them, and finally with the last snap (all three of which had consumed less than a minute) all had reached their crevices.

On June 2 and the six following evenings, these tests were repeated at about 9:30 p.m., and on three of the evenings an

additional experiment was done at 1 a.m. There were always from fifteen to twenty adults on the floor, and in all nine of the trials of the three thumb-nail tests each given at short intervals, the entire population was driven completely to cover at the opposite end of the cage.

Their reactions in darkness differed from those of daylight in that all were in perfect accord in their movements toward their shelter when the sounds were made against the glass. Here were experiments on insects at a normal time of activity in their natural habitat. They had been in this box for several weeks, and they remembered the geographical position of each crevice; the work was carried on under conditions of darkness that were in accord with their normal activities. They heard sharp sounds in the dark when they were away from their crevices and acted voluntarily—or, one may say, instinctively—and beat a hasty retreat to a haven they knew. During the daylight hours, even though possessed with the instinct to run, indecision caused some to respond by movement and others by remaining quiet. This quick response is probably due not to darkness alone, but in part to the fact that the roaches were experimented upon in their own home, where every crevice and corner was familiar to them, and in times of danger they remembered their places of shelter and headed directly to them.

Here again the ghost of "tactile perception" bobs up; at first sight it may seem that the snapping of the thumb-nail against the glass may have vibrated the container, ever so slightly, and the reaction noted in the roaches may be due to tactile perception rather than auditory. There are two things that militate against tactile perception in these tests. It is unlikely that the snapping of the finger-nail against the glass would have caused

the heavy container (it was made of iron, slate and plate-glass, had a plate-glass cover and weighed at least fifty pounds) to shake. Also, often before a test was begun, I shook the table slightly and found it aroused no response in the roaches. Since these shakings did not elicit tactile reaction, one may safely say that the response to the thumb snaps must have been due to auditory perception.

There is still another test indicating auditory rather than tactile perception. I had about fifty adult oriental roaches of both sexes in a large tin candy-can. By dim light at night I would often tap the can with a pencil at intervals. This noise created a scramble by the roaches for cover under pieces of paper. Now in this case vibrations in the tin might have carried tactile as well as auditory stimuli; but that was not all. I soon discovered that tapping the tin can with a pencil caused active responses in two colonies of roaches in glass fish-bowls on another table near by. This latter incident seems to be an unquestionable case of auditory perception, since the roaches in the glass bowls were quite beyond the reach of any vibrations other than sound.

Further evidence that Oriental roaches respond to sound was obtained when the glass lid of one of the jars was lifted and accidentally slipped from the fingers. The noise, as the lid hit the jar, caused the roaches within to run for cover. They, however, may have been influenced by the movement of the air within the jar or by the vibration of the vessel, rather than by the sound of the falling lid; the significant point is that roaches in neighboring jars, some little distance away, also reacted in the same way. To make sure that nothing but sound influenced these reactions, the experiments were repeated several times after the jars had been well upholstered with wads of cotton. The results

were always the same; some of the inmates of the neighboring jars always moved with alarm. Finally, to eliminate all possibility of tactile influences, the neighboring jars were removed to a nearby table and the test repeated. The results were the same as before. These experiments were carried on during daylight hours but in no case did all the roaches so react. Later, when the same tests were made at night with the aid of a dim flash-light, the reactions of roaches in neighboring jars were positive to the extent of 100 per cent of their number. The experiments described for adult Oriental roaches were also tried on adults and large nymphs of the American roach with the same positive results.

There is yet another by-product of these thumb-tapping experiments. The work was carried on for six successive nights, but toward the end it took louder taps, and more of them, to frighten the population to run for shelter. The roaches were learning that these sounds were not of life significance, and refused to respond as rapidly as they did early in the work. In the first few days, three taps and one minute of time was all that was necessary to bring the population to their places of shelter. The work was carried incidentally for several nights beyond the sixth; on the tenth and eleventh nights it required twelve to fourteen taps, consuming several minutes, to get them all into their crevices.

Periplaneta americana

The same thumb-tapping experiments were practiced a month later on American roach nymphs in the last instar. The results were almost identical with those for the same tests on the oriental roaches. Three snaps of the thumb at measured intervals of about a half-minute brought the flock to the crevices at the opposite

end of the box. It was with greater difficulty, however, that the tests were begun, because these roaches were more sensitive to the dim rays from the flashlight than were the oriental roaches. It required about six nights of practicing with a dim flashlight before they became conditioned to it and did not run.

giving 61 positive responses out of 90 tests (67.7 per cent), and that none of them responded to 6000 vibrations per second.

Paracoblatta pensylvanica

A few wood-roaches were trapped in the barn and subjected to tests of tub-

TABLE 7
Results of hearing tests made on three nymphs of *Periplaneta americana*

1	2	3	4	5	6	7	8	9	10	11	
NO.	DATE 1937	TEMPERATURE F.	TUB BANG				6000 VIBRATIONS				AGE
			No. Trials	No. Tests	Negative	Positive	No. Trials	No. Tests	Negative	Positive	
10	9/26	64	2	20	6	14	2	10	10	0	$\frac{1}{2}$ grown
26	10/19	59	1	5	0	5	—	—	—	—	$\frac{1}{2}$ grown
55	4/21	67-80	7	65	23	42	5	45	45	0	In last instar
Total.....			10	90	29	61	7	55	55	0	
Per cent.....						67.7%					

TABLE 8
Results of hearing tests made on adult wood roaches, *Paracoblatta pensylvanica*

1	2	3	4	5	6	7	8	9	10	11	12	
SEX	NO.	DATE 1938	TEMP. F.	TUB BANG				6000 VIBRATIONS				REMARKS
				No. Trials	No. Tests	Negative	Positive	No. Trials	No. Tests	Negative	Positive	
F	108	5/30	72	2	10	6	4	2	16	6	10	Ate bread between tests
F	111	5/31	76	2	10	6	4	1	5	3	2	Became adult 5/17
F	112	5/31	80	1	10	2	8	3	30	11	19	Became adult 5/17
M	113	5/31	74	1	10	2	8	—	—	—	—	Became adult 5/15
F	114	6/15	76	2	15	6	9	3	25	16	9	
Total.....				8	55	22	33	9	76	36	40	
Per cent.....							60%				52.6%	

After they had become indifferent to this, I inaugurated the tests, and was successful in getting them to respond to the sounds in the dim light. There were twenty large nymphs in these experiments.

Tests were made on three nymphs $\frac{1}{2}$, $\frac{1}{3}$ and $\frac{7}{8}$ grown, of the American roach.

In Table 7 we see that all three nymphs responded to the banging of the tub,

banging and also to vibrations of 6000 cycles.

Here (Table 8) we see adults of both sexes responding equally well to the two kinds of tests. In the tub-banging tests, 33 out of 55 (or 60 per cent) responded positively, and in the 6000-cycle experiments, 40 in 76 tests (52.6 per cent).

The behavior of this species on the ex-

perimental platform differed decidedly from that of the oriental roach. The latter would give a quick jerk or run, but *Paracoblatta* would always jerkily move toward the left. In this manner, with hardly any movement of the rear part of the body, with each alarm they would swing the fore-part of the body a little more to the left to the extent of about thirty degrees for each move; they would thus describe about one-third of a circle in four reactions.

The behavior of Female 114 was of interest, for she always reacted a few seconds after the sound had ceased.

SUMMARY AND DISCUSSION

The observational and experimental data herewith presented definitely establishes the fact that the oriental roach, *Blatta orientalis*, perceives and responds to such sounds as banging of doors, peals of thunder, blasts of dynamite and the beating of metal tubs. Both sexes in the adult stage respond to all these sounds, while nymphs of unknown sex respond to some of them. The percentage of responses to the tub-banging experiments, for example, was 68.2 per cent for the nymphs, 67 per cent for the adult females, and 51.2 per cent for the adult males.

Tests with the audio-oscillator brought forth very few responses; this does not imply, however, that they did not hear these sounds, but rather as the comments in earlier pages indicate, the sound was heard but response was withheld. This inhibition of movement was very probably due to the fact that the insects, naturally nocturnal in habit, were subjected to experiments during daylight hours or during the night with artificial lighting, and also while they were away from their natural haunts. With roaches under normal conditions in their own homes, in other tests by snapping the thumb-

nail against the glass, we got 100 per cent response from adults of both sexes for the Oriental and also the American roach.

In the wood-roach, *Paracoblatta pensylvanica*, we find the insects responding to the banging experiments as well as the 6000 vibrations; in the former they reacted in 60 per cent of the tests, and in the latter, 52.6 per cent. The smaller nymphs of the American roach gave favorable responses to the tub-banging tests in 67.7 per cent, but none at all to 6000 vibrations.

CONCLUSIONS

A survey of the literature on the subject of sound perception leaves one with the conviction that the great weight of evidence is in favor of sound perception or hearing in insects, and all this without bringing to the aid of the problem the proofs advanced on morphological grounds. Time, after all, seems to be the perfect judge, and the early experiments and results that have long been viewed with suspicion, now presented in the light of recent investigations, are regarded in a different light. Where observers have obtained negative results, it may in some cases have been due to technique, as compare for instance the observations by Hopkins (Marlatt 1898) on cicadas with those of Fabre. In other cases it is a question whether the sounds used were of a kind that meant anything biologically in the lives of the insects; in other cases, surroundings may have caused a difference, as when ants were observed at home in their own nests or in places strange to them.

Insects were in song long before man came upon earth, and "there is good palaeontological evidence that grasshoppers not greatly different from present day forms fiddled away among the carboniferous ferns and enlivened the dense atmosphere of preadamite times" (Riley,

1874); and Zeuner (1934) in tracing the evolution of fiddle and of ear in locusts and crickets from the upper Palaeozoic says in Tettigoniidae and Gryllidae, the ear in the tibia of the foreleg, is evidently older than the muscial apparatus.

Insects use sound primarily with biological meaning to call and charm mates, as in the crickets and katydids; to escape

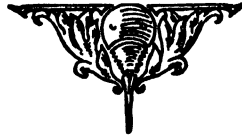
danger, as in the roach; to compete with rivals for mates; to call members of the same colony as in social insects; and finally to express the pure joy of living. To give biological meaning to the production of sound, it is necessary for the insects to be able to hear sound, and I think the evidence herein submitted points to that conclusion.

LIST OF LITERATURE

- ABBOTT, C. E. 1927. The reaction of *Datana* larvae to sounds. *Psyche*, 34: 129.
- ALLARD, H. A. 1911. The stridulations of two interesting Locustidae. *Psyche*, 18: 118-119.
- . 1929. Our insect instrumentalists and their music. *Smith. Report* for 1928. 563-591.
- . 1930. The chirping of the snowy tree-cricket. *Canad. Ent.*, 62: 131-142.
- ANDREWS, E. A. 1911. Observations on the termites of Jamaica. *Jour. Animal Behavior*, 1: 193-228.
- ARMBRUSTER, L. 1914. Probleme des Hummelstaates. *Biol. Cent.*, 34: 685.
- . 1922. Vom Hören der Insekten (Bienen). *Die Naturwissenschaften*, 10: 602.
- BAIER, L. J. 1930. Contributions to the physiology of the stridulation and hearing of insects. *Zool. Jahrb. Abt. allg. Zool.*, 47: 151-248.
- BATES, H. W. 1863. The Naturalist on the River Amazon. *London*.
- BAUMGARTNER, W. J. 1911. Observations on the Gryllidae. *Kansas Univ. Sci. Bull.*, 5: No. 18 (1910) 309-319.
- BETHE, A. 1900. Noch Einmal über die psychischen Qualitäten der Ameisen. *Pflügers Arch.*, 79: 39.
- BUTTEL-REEPEN, H. VON. 1907. Are Bees Reflex Machines? Trans. by M. H. Geisler. *Medina, Ohio*.
- CAUDELL, A. N. 1906. *Jour. N. Y. Ent. Soc.*, 14: 32-45.
- CHESHIRE, F. R. 1886-88. Bees and Bee-keeping.
- COLLENETTE, C. L. 1928. An *Ageronia* (Lepidoptera) responding to a noise made by birds. *Ent. Monthly Mag.*, 64: 178-179.
- COMSTOCK, A. B. 1911. How to Keep Bees.
- DARWIN, C. 1894. The Descent of Man. 2nd Ed.
- EGGER, F. 1925. Versuche über das Gehör der Noctuiden. *Zeit. für. vergleich. Physiol.*, 2: 297-314.
- ELtringham, H. 1933. The Senses of Insects.
- EMERSON, A. E. 1928. Communication among termites. *Proc. Fourth Intern. Cong. Entom. Ithaca*, (issued 1930) 1: 712-717.
- EMERY, C. 1893. Zirpende und Springende Ameisen. *Biol. Cent.*, 13: 189.
- ESSENBERG, C. 1915. The habits of the water strider, *Gerris remiges*. *Jour. Animal Behavior*, 5: 397-402.
- FABER, A. 1929. Sound variations and their biological significance. *Zeitschr. Wiss. Biol. Abt. a. Zeitsch. Morph. u. Ökol. Tierre.*, 13(3/4): 745-803.
- FABER, H. 1919. The Life of the Grasshopper. Trans. by A. T. de Mattos. N. Y., 78-80.
- FIELDE, A. M. and PARKER, G. H. 1904 The reactions of ants to material vibrations. *Proc. Phila. Acad. Nat. Sci.*, 56: 642.
- FOREL, A. 1888. Sur les sensations des insectes. *Recueil Zool. suisse*, T. 4, No. 2.
- . 1908. The Senses of Insects. Trans. by Macleod Yearsley.
- . 1930. The Social World of the Ants.
- FULTON, B. B. 1925. Physiological variation in the snowy tree-cricket. *Oecanthus niveus*. DeGeer. *Ann. Ent. Soc. Amer.*, 18: 363-383.
- . 1928a. A demonstration of the location of auditory organs in certain Orthoptera. *Ann. Ent. Soc. Amer.*, 21: 445-448.
- . 1928b. Sound perception by insects. *Scientific Monthly*, 27: 552-556.
- . 1933. Stridulating organs of female Tettigoniidae. *Ent. News.*, 64: 270-275.
- GRABER, V. 1882. Die chordotonal Sinnesorgane und das Gehör der Insekten. I. *Arch. f. mikr. Anat.*, 20: 506.
- HAMANN, W. 1909. Haben Schmetterlinge Gehörsinn? *Intern. Ent. Zts.*, 3: 141, 144-146.
- HANCOCK, L. H. 1911. Nature Sketches in Temperate America. *Chicago*.
- HEINRICH, R. 1909. Haben Schmetterlinge Gehörsinn? *Entom. Plauderi. Intern. Ent. Zts.*, 2: 275-277.

- HUBER, P. 1820. Natural History of Ants.
- HUNGERFORD, H. B. 1924. Stridulation in *Buenoa limnocastoris*. *Ann. Ent. Soc. Amer.*, 17: 223-236.
- IMMS, A. D. 1931. Recent Advances in Entomology. London and Philadelphia.
- JANET, C. 1893. Note sur la production des sons chez les fourmis et sur les organes qui les produisent. *Ann. Soc. Ent. France*, 62: 159.
- . 1894. Sur les nerfs de l'antenne et les organes chodolonaux chez les fourmis. *C. r. Acad. Sci. Paris*, 118: 814.
- KELLOGG, V. L. 1905. American Insects. New York.
- KRONING, F. 1925. Ueber die Dressur der Biene auf Tonc. *Biol. Zent.*, 45: 496.
- LATOTTE, F. 1929. Expériences sur le psychisme du frelon (*Vespa crabro*). *Bull. Soc. Zool. Fr.*, 54: 630-639.
- LUBBOCK, JOHN. 1888. On the Senses, Instincts and Intelligence of Animals. London.
- . 1929. Ants, Bees and Wasps. Edited and annotated by J. G. Myers.
- LUTZ, F. E. 1924. Insect sounds. *Bull. Am. Mus. Nat. Hist.*, 50: 333-372.
- MCINDOO, N. E. 1922. The auditory sense of the honey bee. *Jour. Comp. Neurology*, 34: 173-179.
- MARLATT, C. L. 1898. The periodical cicada. *U. S. Dept. Agriculture, Bull.* 14: 57-59.
- MAYER, A. M. 1874. Experiments on the supposed auditory apparatus of the mosquito. *Amer. Nat.*, 8: 577-592.
- METCALF, M. M. 1900. Hearing in ants. *Science N. S.*, 11: 194.
- MIAL, L. C., and A. DENNY. 1886. The Structure and Life History of the Cockroach. London, p. 112.
- MINNICH, D. E. 1925. The reaction of the larva of *Vanessa antiopa* to sounds. *Jour. Exp. Zool.*, 42: 443.
- . 1936. The responses of caterpillars to sounds. *Jour. Exp. Zool.*, 72: 439-453.
- MYERS, J. G. 1929. Insect Singers, a Natural History of the Cicadas. London.
- , and I. H. MYERS, 1928. The significance of cicada song. *Psyche* (British), 8: 40-57.
- ORMEROD, E. L. 1868. British Social Wasps. 74. London.
- PEARMAN, J. V. 1929. On sound production in the Psocoptera. *Ent. Monthly Mag.*, 64: 179-186.
- PECKHAM, G. W., and E. G. 1887. Some observations on the special senses of wasps. *Proc. Nat. Hist. Soc. Wisc.*, p. 104.
- POULTON, E. B. 1896. On the courtship of European Acrididae. *Trans. Ent. Soc. London*, 233.
- . 1921. The courtship of cicada, *Monemotopa insignis*. *Proc. Ent. Soc. London*, June, p. LXIII.
- PUMPHREY, R. J., and A. F. RAWDON-SMITH. 1936a. Hearing in insects; the nature of the response of certain receptors in auditory stimuli. *Proc. Roy. Soc. London, Ser. B.*, 121: 18-27.
- . 1936b. Sensitivity of insects to sound. *Nature* (London), 137: 990.
- . 1936c. Synchronized action potentials in the cercal nerve of the cockroach (*Periplaneta americana*) in response to auditory stimuli. *Jour. Physiol.*, 87: 4-5.
- RAU, P. 1933. Jungle Bees and Wasps of Barro Colorado Island. Published by the author.
- . 1939. Studies in the ecology and behavior of Polistes wasps. *Bull. Brooklyn Nat. Soc.*, 34: 43.
- ROSEN, J. 1912. Experimentelle Untersuchungen über das Gehör von *Liogorillus campestris* L. *Zool. Anz.*, 40: 305, 505-516.
- . 1926. Über die Beeinflussung von *Thamnobotris apterus* Fab., durch künstlich erzeugte Töne und verschiedenartige Geräusche. *Akad. Wiss. Wien. Math. Nat. Kl. Sitzungen. Abt.*, 1: 135, 329-368.
- RICHARDS, O. W. 1927. Sexual selection and allied problems in insects. *Biol. Reviews*, 2: 315-317.
- RICHTER, O. 1909. Können Schmetterlinge hören? *Intern. Ent. Zs.*, 3: 124-126.
- . 1910. Gesicht und Gehör bei dem Schmetterlinge. *Intern. Ent. Zs.*, 4: 42-43, 45-47, 51-53.
- RILEY, C. V. 1874. Katydid. *Sixth Ann. Rep. Insects of Mo.* 150-169.
- ROTHKE, M. 1909. Zum Hörenvermögen bei Schmetterlinge. *Intern. Ent. Zs.*, 3: 162-164.
- SNODGRASS, R. E. 1928. The mind of an insect. *Smith. Rep. for 1927*, 384-416.
- STAEGER, R. 1928. A translation of a review appearing in *Kosmos* (Stuttgart) anonymously in *Literary Digest*, N. Y. May 12, 1928.
- TOWER, W. L. 1906. Evolution in Chrysomilid beetles of the genus *Leptinotarsa*. *Carnegie Publication*, No. 48.
- TURNER, C. H. 1907. The homing of ants. *Jour. Comp. Neurol. and Psychol.*, 17: 367-435.
- . 1913. Behavior of the common roach, *Periplaneta orientalis* on an open maze. *Biol. Bull.* 25: 360.
- . 1914. An experimental study of the auditory powers of the giant silkworm moths. *Biol. Bull.*, 27: 325.
- , and SCHWARZ, E. 1914. Auditory powers of the *Catocala* moths: an experimental field study. *Biol. Bull.*, 27: 275.

- TURNER, C. L. 1916. Breeding habits of Orthoptera. *Ann. Ent. Soc. Amer.*, 9: 118.
- VOGEL, R. 1923. Über ein tympanales Sinnesorgan, das mutmassliche Hörorgan der Singzikaden. *Zeits. Anat. u. Entwicklungs.*, 67: 190.
- WARDEN, C. J., JENKINS, T. N., and WARNER, L. H. 1934. Introduction to Comparative Psychology. N. Y.
- WASHBURN, M. F. 1926. The Animal Mind. Third Edition.
- WARMANN, E. 1891. Zur Frage nach dem Gehörsvermögen der Ameisen. *Biol. Centralb.*, 11: 26.
- WEAVER, E. G. 1935. A study of hearing in the sulphur-winged grasshopper, *Arphia sulphurea*. *Jour. Comp. Psychology*, 20: 17-20.
- , and BRAY, C. W. 1933. A new method for the study of hearing in insects. *Jour. Cell and Comp. Physiol.*, 4: 79-93.
- WELD, L. D. 1899. The sense of hearing in ants. *Science N. S.*, 10: 766-768.
- WHEELER, W. W. 1903. Ethological observations on an American ant. *Jour. für Psych. und Neur.*, 2: 31, 64.
- , 1910. Ants, their Structure, Development and Behavior. New York.
- WILL, T. 1885. Das Geschmacksorgan der Insekten. *Leipzig*.
- ZEUNER, F. 1934. Phylogensis of the stridulating organ of insects. *Nature, (London)* 134: 460.





CHROMAFFIN TISSUE AND PARAGANGLIA

By W. HENRY HOLLINSHEAD

Department of Anatomy, Duke University School of Medicine

INTRODUCTION

ALTHOUGH there is a voluminous literature on the subject of chromaffin tissue, and more especially on the adrenal medulla or its homolog in lower forms, a general consideration of the tissues frequently referred to as "paraganglia" does not seem to be available. Much of the early work on various aspects of this subject has been reviewed by Kohn ('02). In quite recent years, however, interest has been revived by the discovery of additional cell groups resembling chromaffin tissue in certain respects, and by new anatomical and physiological findings on some of the bodies previously described as chromaffin. The term paraganglion, originally synonymous with chromaffin tissue, has been extended by many writers to include those cell groups of non-chromaffin nature which they believe to be homologous with the true chromaffin tissue. It is proposed, then, to consider especially in this article the extra-adrenal mammalian tissues which have at one time or another been classified as chromaffin (chromophil, phaeochrome) or as paraganglia.

Among the tissues which have been thus classified are the abdominal chromaffin bodies, the coccygeal body, the carotid body, certain paraganglia in the region of the heart and great vessels, and the abdominal vagal paraganglia reported by Goormatigh ('36) in the mouse. In order to avoid too much confusion, it is proposed to discuss these structures in the

order in which they have been listed above.

THE ADRENAL MEDULLA AND THE ABDOMINAL CHROMAFFIN SYSTEM

The now well-known reaction which the adrenal medulla gives with chromium salts, resulting in a rather characteristic yellow to brown coloration, apparently was first reported by Henle (1865). In 1890 Stilling observed, during the course of some experiments on the adrenal gland, that the coeliac plexus of the rabbit, cat, and dog contained small masses which were similar, both in their general histology and in their reaction to bichromate, to the cells of the adrenal medulla. Restating his results in 1899, he called these cell masses "the chromophil cells and bodies of the sympathetic."

Similar masses of like nature were subsequently reported to be present in the sympathetic chains and plexuses of many animals, including the human, so that in his classic paper of 1903 Kohn was able to cite more than a dozen papers concerned directly with the presence of extra-adrenal abdominal "chromaffin" tissue, as he preferred to call it. Because of the close connection between the chromaffin tissue and the sympathetic system, especially in their origin, Kohn proposed also the name paraganglion, a term which has been generally adopted, and also, as we shall see, probably much abused. To a particularly large mass of this tissue in the cat and rabbit, situated ventral to the aorta between the superior and inferior

mesenteric arteries, Kohn gave the name chief abdominal paraganglion (*das abdominale Hauptparaganglion*). Vincent ('10) from whose paper Figure 1 was taken, confirmed the presence of this latter body in many animals, and showed that it was essentially similar in histology to the adrenal medulla. Wislocki ('22), by the use of an improved technique for producing the chromaffin reaction, demonstrated its existence in several mammals in which Vincent had failed to find it.

In the human newborn and fetus, similar, but apparently always paired, masses were first demonstrated by Zuckerkandl ('01) in the aortic plexus at about the level of the inferior mesenteric artery. Although he described them under the term *Nebenorgane des Sympathicus*, and they are obviously the homolog, in a slightly different position, of the chief abdominal paraganglion, these bodies are now usually referred to as the "organs of Zuckerkandl." The organs of Zuckerkandl are apparently reduced in size, or lacking, in the adult. The chief abdominal paraganglion of Kohn is said to be absent also in the adult mouse, and usually in the adult rat. According to Goormatigh ('28), it is present in the newborn mouse, but subsequently breaks up into small masses which are distributed throughout the lower abdomen and pelvis.

Chromaffin bodies of macroscopic or microscopic size, or both, seem to have been reported in all mammals in which a careful search for them has been made. These paraganglia may vary from a few cells, or even single cells, usually adjacent to or imbedded in sympathetic ganglia and plexuses, to masses as large as 7 cm. in length and up to 5 mm. in width. The relative amount of this tissue outside the adrenal, as compared to that contained within the gland, has been variously estimated, with no real agreement. Kahn

('12) calculated that the mass of the chief abdominal paraganglion in the dog represented only about one-fourth to one-tenth that of both adrenal medullae; Wiesel ('06) went to the other extreme, in describing a paraganglion (not certainly identified since then) on the heart of the human, which, in itself, usually equalled or exceeded the combined mass of both adrenal medullae. Pearlman and Vincent

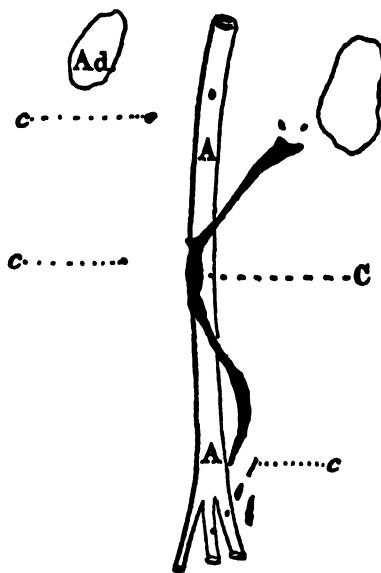


FIG. 1. DIAGRAM OF THE CHIEF ABDOMINAL PARAGANGLION, AND SEVERAL SMALLER CHROMAFFIN MASSES IN THE ABDOMEN OF AN ADULT DOG

A = aorta; Ad = adrenal; C = chief abdominal paraganglion; c = smaller chromaffin bodies. (Redrawn from Vincent, Fig. 1, p. 506.)

('19) suggested merely that the total mass of extra-adrenal chromaffin tissue may exceed that contained in the adrenal glands.

Some characteristics of chromaffin tissue

The chromaffin reaction. The earliest indications of the identity of these cell masses with the chromaffin cells of the adrenal medulla were, as we have seen, in part the general microscopic similarity

between the arrangements of the two tissues, but in much larger part the fact that both gave a similar reaction when treated with bichromate. Indeed, this reaction has remained one of the chief criteria. However, the reaction of the adrenal cells with potassium bichromate is said to be a relatively simple one (Ogata and Ogata, '17), probably depending upon the reduction of the bichromate to CrO_2 . It does not seem improbable that substances other than the epinephrine or its precursor, found in the adrenal medullary cells or their homologs, might give a similar reaction. This possibility was early recognized by several writers, and led therefore to attempts to compare these tissues in other ways.

Origin of chromaffin tissue. Since the development of the adrenal medulla and the ganglia of the solar plexus from a common source was already known at the time of discovery of the abdominal chromaffin tissue, attention was naturally directed toward the embryological origin of this latter tissue also. Thus Zuckerkandl (*op. cit.*) included, in his description of the organs that bear his name, a short account of their origin as he observed it in the fetus. He described two types of cells arising from a common mass along the aorta; a small, dark-staining type which differentiated into nerve cells of the sympathetic ganglia, and a larger, pale-staining type which gave rise to the adrenal medulla and the *Nebenorgane* of the sympathetic. The *Nebenorgane* became disconnected from the adrenal medulla through the poorer development of their upper ends, only a few microscopic bodies persisting there. The lower ends enlarged, apparently up to term, to form the paired organs of Zuckerkandl.

Similar observations were made by Kohn ('03) on the origin of the chief aortic paraganglion and of the smaller

chromaffin bodies in mammals other than the human. Indeed, the very term paraganglion implies a body of which the chief component differentiates from cells which are at one stage indistinguishable from those which are to form ganglion cells. Judged by this criterion, the so-called abdominal chromaffin bodies seem to be truly homologous with the similar cells of the adrenal medulla.

Effects of extracts. Following the discovery of Oliver and Schäfer in 1895, that extracts of the adrenal medulla produced rather typical effects upon the cardiac rhythm and blood pressure, an enormous literature has grown up about the subject of epinephrine and its physiological and pharmacological actions. It is not within the scope of this paper to summarize the findings and controversies in this field; the interested reader will find some discussion of this subject in reviews by Hoskins ('22) and Stewart ('24), and in numerous papers by Cannon and his co-workers. Regardless of these controversies, it seems to be well established that epinephrine, when injected in suitable doses into an intact animal, produces a fairly characteristic rise in blood pressure. Taking advantage of this basic finding, Biedl and Wiesel ('02) prepared extracts of the organs of Zuckerkandl from human fetuses and new-born, and showed that they produced effects quite similar to those of adrenal medullary extracts. The extracts on the whole were somewhat less powerful than those of the adrenal medulla, but resembled them qualitatively in every respect in which they were compared. As control extracts, prepared from retroperitoneal tissue in the neighborhood of the organs of Zuckerkandl, gave no such effects, Biedl and Wiesel felt no hesitancy in declaring that the adrenal medulla and the organs of Zuckerkandl were similar

endocrine organs, producing within their cells a similar chemical substance (adrenin, adrenaline, epinephrine).

The action of extracts of the abdominal chromaffin tissue (primarily of the chief abdominal paraganglion of Kohn) of mammals other than the human has been investigated by various workers (Vincent, '10; Kahn, '12; Fulk and Macleod, '16). They have reported results in agreement with the findings of Biedl and Wiesel on the organs of Zuckerkandl in the human. Vincent and Kahn both obtained typical effects upon blood pressure by injection of their extracts; Kahn used other physiological tests also (production of pupillary dilation in the frog, glycosuria in the rabbit), and, comparing the potency of extracts of adrenal medulla with those of the chief abdominal paraganglion, concluded that the latter contained from one-third to one-fourth as much epinephrine as did a similar weight of medulla. Fulk and Macleod, applying the most precise physiological tests known to them, found that their extracts (including also those from human material) gave effects qualitatively identical with those produced by epinephrine.

It must be admitted that this method of investigation of chromaffin tissue, the preparation of extracts and the determination of their pharmacological properties, is subject to various limitations. The small size of many of the groups of suspected chromaffin cells constitutes a major difficulty. It is obviously almost, if not quite, impossible to prepare extracts of tissue which can be located only in microscopic sections, and then frequently only after treatment with bichromate. For this reason, the tacitly accepted belief that the smaller chromaffin bodies also elaborate epinephrine is based upon their apparent homology with the larger groups of cells, rather than upon the experimental

demonstration of this secretion. Some physiological evidence for this secretion, however, is found in the fact that tumors which apparently arise from this tissue may produce an elevation of blood pressure quite similar to that produced by tumors of the adrenal medulla (Howard and Barker, '37).

Nerve supply. In addition to these methods of investigation, there is one further criterion which may be applied to tissue suspected of being true chromaffin tissue. This is its innervation. Dreyer (1899) apparently first demonstrated that stimulation of the nerves to the adrenal gland leads to an augmented output of epinephrine from the adrenal medulla into the blood stream. Thus it was shown that the cells of the adrenal medulla are at least partially under the control of the sympathetic nervous system—that is, are supplied by motor (secretory) nerves. Elliott ('13) suggested, upon the basis of degeneration experiments which he carried out on these nerves, that this was largely a preganglionic innervation, the preganglionic fibers ending among or upon the medullary cells. Although this idea has been challenged by the casual observations of several workers (e.g. de Castro, '28, p. 370) Hoshi ('27) produced evidence in its support, and the recent experiments of Hollinshead ('36) and Swinyard ('37) seem to have established it upon a firm observational basis. This finding is also supported by the physiological experiments of Feldberg, Minz and Tsudzimura ('34) who showed that acetyl choline was released in the adrenal medulla following splanchnic nerve stimulation (acetyl choline is believed to be typically produced in the sympathetic system at preganglionic, but not at postganglionic, nerve endings).

While it perhaps cannot be maintained that no postganglionic nerve fibers end

upon medullary cells, the preponderance of preganglionic fibers is so overwhelming that there can be little doubt that this is the characteristic type of innervation of the adrenal medulla. It seems to follow from this that tissue which is otherwise identical with the adrenal medulla should have the same type of innervation. This has been shown to hold true both for the chief abdominal paraganglion of the cat and dog, and for at least some of the smaller masses more closely associated with the sympathetic chain (Hollinshead, '37).

This type of innervation, a direct one through preganglionic fibers, has been shown for no other type of tissue (unless the hypothalamico-hypophyseal tracts to the posterior lobe can also be regarded as preganglionic). Therefore, determination of the innervation of a tissue suspected of being chromaffin may throw considerable light upon its true nature. Well-chosen degeneration experiments are not so easily subject to misinterpretation as is the chromaffin reaction itself, and are more easily applicable to small masses of tissue than are experiments involving extraction methods.

To summarize the evidence for the true chromaffin nature of the so-called abdominal chromaffin bodies, we have, first, the appearance of an apparently true chromaffin reaction when treated with bichromate. The identity of this reaction with that given by the adrenal medulla apparently has never been challenged. Second, the embryology of these tissues is usually conceded to be similar to that of the adrenal medulla, though it must be confessed that proof of this, especially in the absence of experimental evidence, is difficult. Third, there is strong evidence that the chief abdominal paraganglion and the organs of Zuckerkandl contain a substance physiologically identical with

epinephrine. Fourth, the innervation of the chief abdominal paraganglion and of at least some of the smaller masses of chromaffin tissue is similar to that of the adrenal medulla, and is different from that of all other types of tissue, so far as known.

Function of the abdominal chromaffin tissue

This question is inextricably bound up with the question of the function of the adrenal medulla. In the early days of investigation on the adrenal, when there was considerable question as to whether the medulla was necessary to life, death following adrenalectomy often was blamed upon removal of this part of the gland. It has been held that chromaffin tissue (the adrenal medulla usually being thought of) played a vital part in the maintenance of normal blood pressure, sugar metabolism, etc. Experiments such as those of Wislocki and Crowe ('24) in which animals remained healthy after destruction of the medulla of both adrenals and removal of the chief abdominal paraganglion, have indicated, however, that chromaffin tissue is not necessary to life. That it may play an important, but not a vital, rôle in the reactions of the animal has been shown by the experiments of Cannon and his co-workers (e.g. Cannon and de la Paz, '11; Cannon, '29). According to their concept, the release of epinephrine under conditions of excitement in the animal leads to a better preparation (increase in heart rate and blood pressure, mobilization of sugar, etc.) toward meeting the emergency which threatens. Under this interpretation, chromaffin tissue is thus thought of as playing a supporting rôle to the sympathetic nervous system, which, according to Cannon, is essentially an emergency mechanism.

To what extent these findings may be applied to the extra-adrenal chromaffin

tissue is not fully known. Since, however, this tissue receives an abundant innervation (Pines, '24; Hollinshead, '37), and since it and the venous blood leaving it (Kahn, *op. cit.*) have been shown to contain an active physiological principle, there can be little doubt that it also participates in the emergency reaction. It must be recalled, however, that the extra-adrenal chromaffin tissue is relatively best developed in newborn and young animals, and may undergo considerable apparent regression with age. According to Goormatigh's ('28) investigations on the mouse, the apparent regression in this animal is due largely to the breaking up and subsequent migration of parts of the larger chromaffin masses. Kohn ('03) and Palme ('34) regard regression of chromaffin tissue, beginning soon after birth, as being peculiar to the human. In this latter species, according to Zuckerkandl (*op. cit.*), there typically occurs considerable hyaline degeneration. It seems necessary to conclude, therefore, that the contribution of the extra-adrenal chromaffin tissue toward the total emergency reaction may vary much in different animals, or perhaps even in the same animal at different ages.

It might perhaps be recalled that there is considerable evidence (see, for example, Dale '38) that epinephrine or a physiologically identical substance is the usual transmitter of the nerve impulse between postganglionic sympathetic fibers and the end organs. The adrenal medulla and the abdominal chromaffin tissue thus stand in the same relation to preganglionic fibers as do the postganglionic neurons of the sympathetic system, and exert their effect upon the end organs through a similar or identical substance. Upon this basis alone, it would be hard to conceive of the function of chromaffin

tissue in terms other than as an adjunct to the sympathetic.

THE COCCYGEAL BODY

This peculiar structure, located on the middle sacral artery or its branches, has occasionally been referred to as a chromaffin body. The observations of Stoerk ('07), and of von Schumacher ('08), have indicated that its constituent cells do not give the chromaffin reaction, and that it is not developed in relation to sympathetic ganglia. According to both these authors, the epithelioid cells in this body are probably hypertrophied elements of the media of the vessels. While there is apparently no direct physiological evidence concerning the function of this structure, there is nothing to indicate that it should be classed as a paraganglion or as chromaffin tissue. On the basis of its structure von Schumacher has interpreted it as an arterio-venous anastomosis between the middle sacral artery and vein.

THE CAROTID BODY

Stilling (*op. cit.*) included this organ among his "chromophil" bodies. Previous to that time it had been variously described as a misplaced ganglion of the sympathetic (intercarotid ganglion), as a glandular structure (intercarotid gland) and as a glomus. Kohn ('00) investigated both the morphology and embryology of this structure, and concluded that it arose in common with the anlage of the sympathetic ganglia (and thus was a paraganglion) and that its cells showed the chromaffin reaction. Both these conclusions have been challenged at various times, but it is to de Castro ('26, '28) that we owe the beginning of the development of our present conception of this organ.

In a careful investigation of the morphology and the nerve supply of the

carotid body, or, as he preferred to call it, the carotid glomus, de Castro produced rather convincing evidence that its cells did not give a true chromaffin reaction. He showed that the so-called chromaffin reaction here was probably not due to the presence of epinephrine, as denervation of the body produced no increase in the intensity of the reaction, and insulin shock produced no decrease in its intensity. He was unable to obtain the reaction with ferric chloride which also denotes the presence of epinephrine (Vulpian, 1856). He concluded that the apparent chromaffin reaction, which he described as differing somewhat from the true chromaffin reaction in appearance, was due to the richness of lipoids in some of the cells. De Castro's evidence has raised considerable doubt as to the specificity of the chromaffin reaction, and made the interpretation of an apparent reaction more uncertain. According to certain authors (e.g. Smith, '24; Boyd, '37) there are, however, some true chromaffin cells in the carotid body of ungulates, though the cells of this body as a whole do not show the reaction.

De Castro further showed that the carotid body receives primarily a sensory innervation through the glossopharyngeal nerve—an innervation which is hardly compatible with a belief in the chromaffin nature of this tissue. He suggested that, in view of the close relation between this body and the pressoreceptor area of the carotid artery (carotid sinus), the carotid body might have a somewhat similar function, but be concerned with the reception of chemical, rather than mechanical, stimuli from the blood stream.

Function of the carotid body

This conception of de Castro's has apparently been fully confirmed by recent physiological work. To summarize the

evidence briefly, Heymans, Bouckaert and Dautreband ('30) and Schmidt ('32) have shown that the region of the carotid bifurcation, in addition to the already demonstrated sensitivity to pressure, is also sensitive to chemical stimuli, and that such stimuli may initiate important vascular and respiratory reflexes. This sensitivity of the carotid sinus region to anoxemia and other respiratory stimulants apparently accounts in part for the respiratory reflexes previously explained as due to direct chemical stimulation of the respiratory center. That the endings in the carotid sinus itself are not responsible for the chemical sensitivity is shown by the work of Bronk and Stella ('35) and Bogue and Stella ('35) in which, by recording the action currents in the nerve of Hering, they showed that the endings in the carotid sinus responded only to pressure changes, while the response to anoxemia and asphyxia persisted after denervation of the carotid sinus. Finally, Heymans and Bouckaert ('33) and Schmidt (*op. cit.*) have found that the response to chemical stimuli in the carotid region was abolished when the carotid body was experimentally excluded from the circulation, although the carotid sinus was still functional.

Effects of extracts. It is obvious that no discussion of the function of the carotid body can be adequate unless such findings as those just mentioned are taken into consideration. This has been clearly recognized by Boyd (*op. cit.*) and by Nonidez ('35b, '36a), who have accepted the carotid body as a primarily sensory structure. In some of the earlier literature, however, (for instance, the papers of Watzka, '30; Penitschka, '31; and Seto, '35) the function of the carotid body is discussed primarily from the standpoint of its supposed elaboration of a vasodepressor principle. While the source of this

theory of the secretory function of the carotid body is usually not given, it probably traces back to the work of Frugoni ('13), who described depressor effects from an extract of the bovine carotid body. Mulon ('04) had previously described pressor effects as following injection of an extract prepared from the carotid body of the horse. According to Christie ('33), Frugoni's experiments are open to serious question, as the effects reported followed only massive doses, and the extract was probably by no means derived only from the carotid body. Christie himself, however, in an apparently carefully controlled research, has obtained vasodepressor effects from an extract of a tumor of the human carotid body. Unfortunately, Christie was apparently not aware that a sensory innervation to this body had already been demonstrated, and has therefore failed to discuss his findings in the light of this knowledge. It is not yet clear what relation the presence of a depressor substance (if further work shall confirm it) may have to the already known functions of this body. It is hard to believe that the secretion of this principle constitutes a separate and important function of the carotid body, as Christie thought at that time. It would seem more probable that such a substance, if present, should rather participate in some way in the apparently proven chemoreceptor function of this organ. Further investigation of this subject is highly desirable, as it may throw additional light on the mechanism involved in the reception of stimuli by this body.

Origin of the carotid body

The facts which we have considered point to a sensory rather than to a true glandular function for the carotid body, and indicate that there is probably noth-

ing in common, other than general arrangement of cells, between this body and the chromaffin bodies. From the embryological side, however, the evidence is not quite so clear. It seems to be granted by practically all investigators that cells do migrate from the cervical sympathetic ganglia, the ganglia of the ninth and tenth nerves, or from all of these, to the region of the carotid body. Opinion is sharply divided, however, as to the part these cells play in the formation of this structure. For instance, the origin of the carotid body has been attributed to sympathetic cells (Kohn, '00) or to the vagospinal ganglion (Benoit, '28). On the other hand, both Smith and Boyd (*op. cit.*) among others, have interpreted the contribution from ganglia of any type as a secondary one. Boyd has described it as making its appearance in the human, as a mesenchymal condensation about the internal carotid artery, before there is any evidence of the migration of cells of nervous origin. This latter he has seen in later stages of development; some of the migratory cells, he believes, become the ganglionic cells frequently found in and about the carotid body; some probably degenerate, while others may persist as small isolated cells which never develop the chromaffin reaction. Boyd denies the presence of cells of nervous origin in the whorls of epithelioid cells which constitute the parenchyma of the carotid body. Smith took an essentially similar view, but believed that the contribution from the ganglia in some species persists to form well-defined chromaffin tissue. She interpreted the carotid body as a complex of chromaffin and non-chromaffin portions, of which the latter is the essential portion of the gland, while the former varies much in different species.

The preponderance of evidence seems

to be against the idea of any fundamental relation between the carotid body and chromaffin tissue. While it is possible that true chromaffin tissue may exist in relation to this body in some species, it is evident that this plays no rôle in the function of the organ, for it is certainly absent in other species. From the functional standpoint, chromaffin tissue and the carotid body seem to be quite unrelated. The embryological evidence offered for or against the homology of the two should be interpreted with caution, as the difficulty of following the fate of specific cells in the region of the branchial arches must be considerable. Experimental evidence such as Stone ('29) has offered for the origin of the branchial cartilages from neural crest in the amphibia might go far toward settling this problem.

THE CARDIO-AORTIC BODIES

Under this heading may be grouped several epithelioid bodies, usually referred to as paraganglia, which are found in the supracardial and lower cervical regions of mammals. (Bodies of similar structure have also been found in corresponding positions in birds and reptiles—Nonidez, 35a; Muratori, '37; Palme, *op. cit.*) The literature concerning them is for the most part recent and relatively scanty, and it is indeed uncertain how many such structures are usually present in any one species. The accompanying figure (Fig. 2) from Boyd (*op. cit.*) shows the location of certain of these bodies in a human embryo.

The supracardial bodies

The first account of paraganglia in the region of the heart was apparently by Wiesel ('06), who reported the presence of a large mass of what he regarded as chromaffin tissue on the heart near the

origin of the left coronary artery. It was this mass which Wiesel described as equaling or exceeding in bulk the combined medullae of the two adrenals, and which, according to Palme (*op. cit.*) has not certainly been identified since that time. Palme quotes Busacchi ('12) as having first recognized the existence of two distinct groups of paraganglia in this region in the human. The upper one lies between the aortic arch and the pulmo-

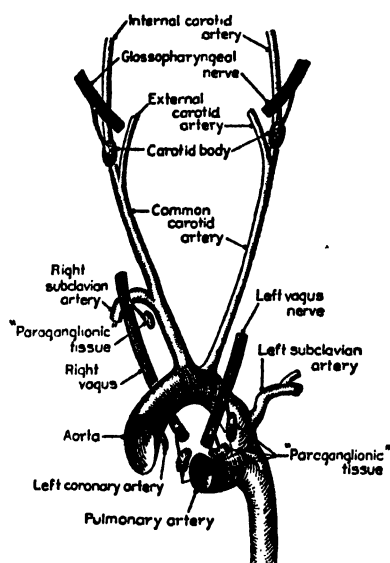


FIG. 2. THE BRANCHIAL ARCH REGION IN A 26 MM. HUMAN EMBRYO, TO SHOW THE POSITIONS OF THE SO-CALLED PARAGANGLIONIC TISSUE ASSOCIATED WITH THE NINTH AND TENTH CRANIAL NERVES

(From Boyd, Fig. 1, p. 27)

nary artery, close to the ductus (ligamentum) Botalli, and was subsequently described by Penitschka (*op. cit.*) as the paraganglion supracardiale, and by Palme as the paraganglion supracardiale superior. Busacchi, Penitschka, and Palme have reported that this is essentially non-chromaffin in staining reaction, although Palme states that some chromaffin cells are apparently present in this body in early fetal stages. The second (lower)

body lies between the pulmonary artery and the ascending aorta, close to the origin of the left coronary artery. According to Palme, this may represent the body reported by Wiesel, though it is much smaller in size. Busacchi apparently regarded this as chromaffin tissue. Palme, also, states that it is largely chromaffin in nature in the fetus, but that in the human adult it is much reduced in size and is represented only by small non-chromaffin groups of cells. These are apparently identical in structure with the paraganglion supracardiale superius. Palme has called this body the paraganglion supracardiale inferius. Seto (*op. cit.*) has described what is apparently the same structure in the adult human heart, and has reported that it is non-chromaffin in nature.

The structure of these bodies in mammals other than the human has been investigated especially by Palme (*op. cit.*), and by Nonidez ('36a, '37a). Their exact homology from one species to another is somewhat difficult to ascertain; however, Palme has found bodies in a corresponding position in the cat and rat, and has reported that the lower one is largely chromaffin in nature, the upper one, non-chromaffin. Nonidez ('36a) made no specific separation between the upper and lower paraganglionic masses in the cat, describing them rather as "irregular masses of rounded epithelioid cells extending from the arch of the aorta to the base of the heart" (p. 215); in a previous paper (Nonidez, '35b; Fig. 1) he has illustrated a similar condition for the rabbit. In the cat, certain of the cells after formol-bichromate fixation contained yellowish granules. Nonidez suggests the possibility that these may be similar to the cells described by de Castro in the carotid glomus of this animal. Nonidez ('37a) has stated that the position of the

two groups in the dog rather closely approximates that in the human, but has reported no observations on these bodies after bichromate fixation.

The aortic bodies

In addition to these epithelioid groups below the arch of the aorta, Nonidez ('35b, '37a) and Muratori ('34, '35) have also described similar bodies above the arch. For these Nonidez ('35b) has suggested the term aortic glomi. They vary somewhat in position, but are usually more or less closely related to the origins of the left and right subclavian arteries, respectively. They apparently are represented in Boyd's figure of the human embryo by the upper masses attached to the two vagus nerves. Tschernjachiwsky ('38) also has reported their presence in the human embryo and infant. According to Nonidez, who has made a very careful investigation of their structure and innervation in the rabbit, cat, guinea pig and dog, they are essentially non-chromaffin in nature, though in the cat certain cells contain fine yellow granules after treatment with bichromate. These are apparently identical with the similar cells in the supracardial paraganglia of this animal.

Aside from the presence of chromaffin cells in the cardio-aortic paraganglia, all the investigators who have studied them agree that they are essentially alike in structure, and in turn closely resemble the carotid body. In the fetus and newborn they may be fairly compact structures located in general along the vagus nerves, and composed of cords or whorls of epithelioid cells which receive a very rich blood supply, usually by a direct branch from the aorta, pulmonary artery, or subclavian artery. In older individuals the balls of epithelioid cells originally forming one fairly distinct mass may be

separated from each other by considerable fat and connective tissue. Small groups of these cells may also be embedded entirely in a nerve trunk (Palme) or in the wall of the aorta or pulmonary artery (Nonidez, Palme).

Nerve supply

Beginning with the work of Penitschka, the writers who have discussed these structures have all pointed out the close relation of these bodies to the vagus nerves, though their actual innervation has been investigated in only a few cases. Palme described fine nerve fibers penetrating the cell groups of the supracardial paraganglia, but left the question of their intimate relation to the cells unsettled. Seto (*op. cit.*) on human material (probably the inferior supracardial paraganglion) described fine fibers, of apparent vagus origin, as ending among the parenchymal cells in a "nervous terminal reticulum"; these he regarded as motor fibers. Nonidez, in his very careful series of studies on the innervation of the bodies above and below the aortic arch in several animals, has also described the fibers as definitely of vagus origin. According to his findings, however, they end freely among the cells, often with small loops or terminal swellings. Tschernjachiwsky (*op. cit.*) has reported similar findings in the human. Nonidez has not found a nervous terminal reticulum in his own preparations, prepared by a different technique than that used by Seto, nor apparently has Muratori ('37) found such a structure. Nonidez has recently presented evidence in another series of papers ('36b, '37b), based upon comparison of tissues stained for reticular tissue and for nerve fibers, that the so-called nervous terminal reticulum is probably composed in reality of fine argyrophil connective tissue fibers. This criticism is of some importance in

the present instance, as it is apparently largely upon the presence of this terminal reticulum that Seto bases his belief that the fibers among the parenchymal cells are motor. Nonidez has interpreted the fibers as sensory, as they are derived, according to his findings, largely from medium-sized or large fibers. Recent degeneration experiments (Hollinshead, '39) have indicated that the nerve fibers in the aortic glomi of the cat arise from cells situated in the ganglion nodosum of the vagus, thus supporting Nonidez' interpretation of their sensory character. Degeneration experiments upon the nerve supply to the bodies below the arch of the aorta have apparently not yet been carried out; it would be rather surprising, however, in view of the apparently identical nature of these bodies with the aortic glomi, if they should prove to have a different type of innervation.

Function of the cardio-aortic bodies

Penitschka, Palme, Muratori, Seto and Nonidez have all pointed out that these bodies are especially related to the pressoreceptor zones on the great vessels near the heart, just as the carotid body is related to the pressoreceptor area of the carotid artery. The last three workers have also described nerve endings of the pressoreceptor type in the vessels to or in the cardio-aortic bodies, as has also Tschernjachiwsky. In so far as these are concerned it seems probable, therefore, that these bodies (or more properly speaking, their vessels) may function as accessory vasodepressor areas. However, this does not explain the function of the parenchyma of these bodies, nor the meaning of the nerve endings among the parenchymal cells. Concerning these matters there have been several tentative opinions ventured. Penitschka suggested merely that these bodies were similar in

function to the carotid body, and probably secreted a vasodepressor substance. Palme was unwilling to grant that they are endocrine glands in the usual sense of discharging a secretion into the vascular system; instead he suggested that "die paraganglionären Zellen Wirkstoffe an die umgebend Nervenfasern abgeben dürften, die den Zustand, vielleicht die Erregungsfähigkeit der betreffenden Nerven örtlich beeinflussen könnten" (p. 419). Seto interpreted the body which he investigated as an endocrine organ, liberating a vasodepressor substance into the blood stream, and representing an *Erfolgsorgan* for the aortic reflex. Muratori ('37) states merely that these structures probably have something to do with the regulation of blood pressure. Nonidez, reviewing their similarity to the carotid body (emphasized by all these investigators), and also the recent literature apparently demonstrating a chemoreceptor function for the carotid body, very logically suggested that the cardio-aortic bodies are also chemoreceptors. This view has also been accepted by Boyd and Tschernjachiwsky. For the present the matter rests here, as there seem to be as yet no physiological experiments bearing directly on this question. Boyd (*op. cit.*, p. 29) has called attention to the fact that the residual sensitivity to anoxemia remaining after section of the nerve of Hering, but disappearing after section of the vagi, may be explained by this supposed function of the cardio-aortic bodies.

Chromaffin tissue in the cardiac region

If we turn now to the presence of chromaffin tissue in the cardiac region, we find relatively little information concerning it. There seems to be no reason why such tissue should not be present in this region, in connection with sympathetic plexuses; according to the reports

of Palme on the human, and of both Palme and Pannier ('35) on the cat, there are collections of true chromaffin cells here. It may be recalled that Palme described the paraganglion supracardiale inferius as being composed in large part of chromaffin tissue, though he distinguished a non-chromaffin portion from this. The fact that the two tissues may perhaps occur in close apposition to each other should not be interpreted to mean that there is either a functional or close genetic connection between the two. The term cardio-aortic bodies, as here used, is limited to the non-chromaffin masses of epithelioid cells; the chromaffin masses, when present, presumably differ in no way from the similar masses in other locations.

ARE THE CAROTID AND CARDIO-AORTIC BODIES PARAGANGLIA?

The whole weight of evidence concerning the cardio-aortic bodies seems to be that they are non-chromaffin in nature, and that they are identical in structure with the carotid body. It seems reasonable to believe that the carotid body and the cardio-aortic bodies are homologous structures which are also similar in function, and can therefore be fairly discussed as a group. The question then arises as to whether these structures can properly be termed paraganglia. In the minds of most of us, probably, this term implies an endocrine organ composed of chromaffin tissue, as that was the original use of the word. Recently however, in the articles from Kohn's laboratory on the supracardial paraganglia (Penitschka, Palme, Seto, Watzka) a distinction has been made between chromaffin and non-chromaffin paraganglia. The former are distinguished by the chromaffin reaction, the presence in their cells of a vasopressor substance (epinephrine), and their innervation through the sympathetic; a

further criterion, applicable only to the human, is that this type undergoes a rapid regression which begins soon after birth. The second type (composed of the carotid and cardio-aortic bodies) is non-chromaffin, is believed by that school to contain (and secrete—Seto) a vaso-depressor substance, and to be innervated through cranial nerves alone, or through both cranial nerves and the sympathetic. The bodies of this type apparently persist in well-developed form throughout life. The two types are frequently fairly separate, but there may (Palme) be considerable admixture of the two. Both types are believed by this school of thought to arise in common with the peripheral ganglionic elements of the nervous system. It appears, therefore, that these two types of tissue are grouped together as paraganglia because of their supposed endocrine natures, their intimate relations to the peripheral nervous system, and their supposed origins from similar elements. On the other hand, they are separated by their reactions to bichromate, and by the differing effects of their extracts.

If these supposed likenesses could be proven, there would certainly be excellent reasons for calling both types of tissue paraganglia. As we have seen, however, the best evidence is against the essentially endocrine nature of the non-chromaffin bodies. Corresponding with this apparently sharp difference in function, their relation to the peripheral nervous system, while perhaps superficially similar, really differs markedly: the chromaffin bodies are related to motor fibers, the non-chromaffin apparently to sensory fibers. The only real linkage between the two groups seems therefore to be their supposed origin from the nervous system. This latter has also been questioned; even if it were proven, the advisability of imposing the same name upon two such

different tissues, simply because they are homologous, might well be doubted. One cannot very well argue with Kohn concerning the usage of the term which he devised; however, it would seem more reasonable to restrict the term paraganglion to neurogenic endocrine organs which seem to be physiologically, as well as embryologically, the equivalent of autonomic postganglionic neurons. The only known example of this today is chromaffin tissue. For the non-chromaffin bodies, especially in the present state of our knowledge, terms such as aortic glomus and carotid glomus, which suggest merely the intimate association between the blood stream and these bodies, or the still more neutral terms carotid body, aortic bodies, etc., seem to be preferable.

THE ABDOMINAL VAGAL PARAGANGLIA

These are small epithelioid bodies described by Goormatigh ('36) along the course of the vagus nerves in the abdomen of the mouse. According to him they are non-chromaffin in nature; he suggests that they may be a parasympathetic homolog of the (sympathetic) chromaffin tissue, and represent secretory organs for the liberation of some substance akin to acetyl choline. Goormatigh has not demonstrated an innervation to these bodies, although his theory demands that they be supplied with motor fibers from the vagus. Until such a demonstration has been made, or until other evidence as to the presence and function of these bodies has been obtained, it seems fruitless to discuss these structures further. It might be added, however, that if Goormatigh's hypothesis concerning the nature of these bodies should prove to be true, they should certainly be termed paraganglia; we would then have two types, sympathetic and parasympathetic

paraganglia, each corresponding in certain important physiological respects to the postganglionic neurons of the system of which they are a part.

SUMMARY

We have seen that the status of the so-called abdominal chromaffin tissue is rather clearly defined. It is generally accepted as being true chromaffin tissue, with the ability to secrete epinephrine. Although the concept of the nervous origin of the adrenal medulla has been bitterly contested by a few workers, it is on the whole generally conceded, and the argument seems equally strong for a similar origin of the extra-adrenal chromaffin

tissue. These two tissues seem to be similar both in origin and in function, and to correspond to the original meaning of the word paraganglion. On the other hand, the carotid and cardio-aortic bodies are non-chromaffin in nature, and apparently represent, as Nonidez ('37a, p. 311) says, "complex neurovascular structures intimately associated with the branchial arches of the embryo." They are presumably sensory in function, probably representing receptors sensitive to chemical changes in the blood, through which vascular and respiratory reflexes are initiated. Their neurogenic origin has not been proven, and the propriety of terming them paraganglia may well be questioned.

LIST OF LITERATURE

- BENOIT, A. 1928. Recherches sur l'origine et la signification du ganglion carotidien (Souris). *Arch. de Biol.*, T. 38, pp. 219-247.
 BIEDL, A., and J. WIEBEL. 1902. Ueber die funktionelle Bedeutung der Nebenorgane des Sympathicus (Zuckerkanal) und der chromaffinen Zellgruppen. *Arch. f. d. ges. Physiol.*, Bd. 91, S. 434-461.
 BOGUE, J. Y., and G. STELLA. 1935. Afferent impulses in the carotid sinus nerve (nerve of Hering) during asphyxia and anoxemia. *J. Physiol.*, vol. 83, pp. 459-465.
 BOYD, J. D. 1937. The development of the human carotid body. *Contr. to Embryol., Carnegie Inst.*, vol. 26, pp. 1-31.
 BRONK, D. W., and G. STELLA. 1935. The response to steady pressures of single end organs in the isolated carotid sinus. *Am. J. Physiol.*, vol. 110, pp. 708-714.
 BUSACCHI, P. 1912-13. *Arch. ital. Anat.*, T. 11. (Cited after Palme.)
 CANNON, W. B. 1929. Bodily changes in pain, hunger, fear and rage. D. Appleton and Co., New York.
 —, and D. DE LA PAZ. 1911. The stimulation of adrenal secretion by emotional excitement. *Am. J. Physiol.*, vol. 28, pp. 64-70.
 DE CASTRO, F. 1926. Sur la structure et l'innervation de la glande intercarotidienne (glomus caroticum) de l'homme et des mammifères, etc. *Trav. du Lab. de Rech. biol. de l'Univ. de Madrid*, T. 24, pp. 365-432.
 —. 1928. Sur la structure et l'innervation du sinus carotidien de l'homme et des mammifères, etc. *Ibid.*, T. 25, pp. 331-380.
 CHRISTIE, R. V. 1933. The function of the carotid gland (glomus caroticum). I. The action of extracts of a carotid gland tumor in man. *Endocrinology*, vol. 17, pp. 421-432.
 DALB, H. 1938. Acetylcholine as a chemical transmitter of the effects of nervous impulses. I. *J. Ms. Sinai Hosp.*, vol. 4, pp. 401-415.
 DREYER, G. P. 1899. On secretory nerves to the suprarenal capsules. *Am. J. Physiol.*, vol. 2, pp. 203-219.
 ELLIOTT, T. R. 1913. The innervation of the adrenal glands. *J. Physiol.*, vol. 46, pp. 285-290.
 FELDBERG, W., B. MINZ, and H. TEUDZIMURA. 1934. The mechanism of the nervous discharge of adrenaline. *J. Physiol.*, vol. 81, pp. 286-304.
 FRUGONI, C. 1913. Études sur la glande carotidienne de Luschka. *Arch. Ital. de Biol.*, T. 59. (Cited after Christie.)
 FULK, M. E., and J. J. R. MACLEOD. 1916. Evidence that the active principle of the retroperitoneal chromophil tissue has the same physiological action as the active principle of the suprarenal glands. *Am. J. Physiol.*, vol. 40, pp. 21-29.
 GOORMATHIGH, N. 1928. L'évolution du tissu paraganglionnaire après la naissance. *C. R. Assoc. Anat.*, T. 23, pp. 169-172.
 —. 1936. On the existence of abdominal vagal paraganglia in the adult mouse. *J. Anat.*, vol. 71, pp. 77-90.

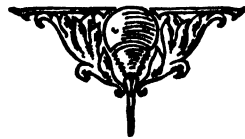
- HANLZ, J. 1865. Über das Gewebe der Nebenniere und der Hypophyse. *Zschr. f. rat. Med.*, Bd. 24, S. 142. (Cited after Ogata and Ogata.)
- HEYMAN, C., and J. J. BOUCKAERT. 1933. Dissociation des deux sensibilités réflexogènes de la bifurcation carotidienne: sensibilité chimique et sensibilité à la pression. *C. R. Soc. Biol.*, T. 112, pp. 1240-1243.
- HEYMAN, C., J. J. BOUCKAERT, and L. DAUTREBAND. 1930. Sinus carotidien et réflexes respiratoires. II. Influences respiratoires réflexes de l'acidose, de l'alcalose, de l'anhydride carbonique, de l'ion hydrogène et de l'anoxémie, etc. *Arch. Internat. de Pharmacodynamie et de Thérapie*, T. 39, pp. 400-448.
- HOLLINSHEAD, W. H. 1936. The innervation of the adrenal glands. *J. Comp. Neur.*, vol. 64, pp. 449-467.
- . 1937. The innervation of the abdominal chromaffin tissue. *Ibid.*, vol. 67, pp. 133-143.
- . 1939. The origin of the nerve fibers to the glomus aorticum of the cat. *Ibid.*, vol. 71, pp. 417-426.
- HOSHI, T. 1927. Morphologisch-experimentelle Untersuchungen über die Innervation der Nebennieren. *Mitt. üb. allg. Path., u. Anat.*, Bd. 3, S. 328-342.
- HOWKINS, R. G. 1922. The relation of the adrenals to the circulation. *Physiol. Rev.*, vol. 2, pp. 343-360.
- HOWARD, J. E., and W. H. BARKER. 1937. Paroxysmal hypertension and other clinical manifestations associated with benign chromaffin cell tumors (phaeochromocytomata). *Johns-Hopkins Hosp. Bull.*, vol. 61, pp. 371-410.
- KAHN, R. H. 1912. Studien an Paraganglien. *Pflüger's Arch. f. ges. Physiol.*, Bd. 147, S. 445-472.
- KOHN, A. 1900. Ueber den Bau und die Entwicklung der sog. Carotisdrüse. *Arch. f. mikr. Anat.*, Bd. 56, S. 81-148.
- . 1902. Das chromaffine Gewebe. *Ergebn. d. Anat. u. Entw.*, Bd. 12, S. 253-348.
- . 1903. Die Paraganglien. *Arch. f. mikr. Anat.*, Bd. 62, S. 263-365.
- MULON, P. 1904. Les glandes hypertensives ou organes chromaffines. *Arch. gén. de Méd.* Année 81, T. 2, Serie Hebdomadaire, pp. 3265-3277.
- MURATORI, G. 1934. Zona recetttrice aortica e tessuto paragangliare. *Boll. Soc. Ital. Biol. Sper.*, T. 8, p. 387. (Cited after Nonidez.)
- . 1935. Connessioni tra tessuto paragangliare e zone recetttrici aortiche in vari mammiferi. *Monist. Zool. Ital.*, Anno. 45, p. 300. (Cited after Nonidez.)
- . 1937. Osservazioni istologiche e considerazioni embriologiche sui recettori aortici degli Amnioti. *Anat. Anz.*, Bd. 83, S. 367-379.
- NONIDIZ, J. F. 1935a. The presence of depressor nerves in the aorta and carotid of birds. *Anat. Rec.*, vol. 62, pp. 47-73.
- . 1935b. The aortic (depressor) nerve and its associated epithelioid body, the glomus aorticum. *Am. J. Anat.*, vol. 57, pp. 259-301.
- . 1936a. Observations on the blood supply and the innervation of the aortic paraganglion of the cat. *J. Anat.*, vol. 70, pp. 215-224.
- . 1936b. The nervous terminal reticulum. A critique. I. *Anat. Anz.*, Bd. 82, S. 348-366.
- . 1937a. Distribution of the aortic nerve fibers and the epithelioid bodies (supracardial 'paraganglia') in the dog. *Anat. Rec.*, vol. 69, pp. 299-317.
- . 1937b. The nervous terminal reticulum: A critique. II and III. *Anat. Anz.*, Bd. 84, S. 1-13 and S. 315-330.
- OGATA, T., and A. OGATA. 1917. Henle's reaction of the chromaffin cells in the adrenals and the microscopic test for adrenalin. *J. Exp. Med.*, vol. 25, pp. 807-817.
- OLIVER, G., and E. A. SCHÄFER. 1895. The physiological effects of extracts of the suprarenal capsules. *J. Physiol.*, vol. 18, pp. 230-279.
- PALME, F. 1934. Die Paraganglien über dem Herzen und im Endigungsgebiet des Nervus depressor. *Zeit. f. mikr.-anat. Forsch.*, Bd. 36, S. 391-420.
- PANNIER, R. 1935. Données générales sur le système ganglionnaire et paraganglionnaire du coeur. *C. R. Soc. Biol.*, T. 120, pp. 1350-1353.
- PEARLMAN, I., and S. VINCENT. 1919. The function of the chromophil tissues. *Endocrinology*, vol. 3, pp. 121-136.
- PENITSCHKA, W. 1931. Paraganglion aorticum supracardiale. *Zeit. f. mikr.-anat. Forsch.*, Bd. 24, S. 24-37.
- PINES, I. L. 1924. Über die Innervation des chromaffinen Gewebes des Sympathicus und über das sympathico-chromaffin System im allgemeinen. *Arch. f. Psychiat. u. Nervenkrankh.*, Bd. 70, S. 636-647.
- SCHMIDT, C. F. 1932. Carotid sinus reflexes to the respiratory center. I. *Am. J. Physiol.*, vol. 102, pp. 94-118.
- VON SCHUMACHER, S. 1908. Über das Glomus coccygeum des Menschen und die Glomeruli caudales der Säugetiere. *Arch. f. mikr. Anat.*, Bd. 71, S. 58-115.
- SETO, H. 1935. Ueber zwischen Aorta und Arteria pulmonalis gelegene Herzparaganglien. *Zeit. f. Zellforsch. u. mikr. Anat.*, Bd. 22, S. 213-231.

- SMITH, C. 1924. The origin and development of the carotid body. *Am. J. Anat.*, vol. 34, pp. 87-131.
- STEWART, G. N. 1924. Adrenalectomy and the relation of the adrenal bodies to metabolism. *Physiol. Rev.*, vol. 4, pp. 163-190.
- STILLING, H. 1890. A propos de quelques expériences nouvelles sur la maladie d'Addison. *Revue de Méd.*, T. 10, pp. 808-831.
- . 1899. Die chromophilen Zellen und Körperchen des Sympathicus. *Anat. Anz.*, Bd. 15, S. 229-233.
- STORCK, O. 1907. Über die Chromreaction der Glandula coccygea und die Beziehungen dieser Drüse zum Nervus sympathicus. *Arch. f. mikr. Anat.*, Bd. 69, S. 322-339.
- STONE, L. S. 1929. Experiments showing the role of migratory neural crest (mesectoderm) in the formation of head skeleton and loose connective tissue in *Rana palustris*. *Arch. f. Entwemeb.*, Bd. 118, S. 40-77.
- SWINYARD, C. A. 1937. The innervation of the suprarenal glands. *Anat. Rec.*, vol. 68, pp. 417-429.
- TSCHERNJACHOWSKY, A. 1938. Sur le développement et sur les terminaisons du nerf dépressur (n. aortique) et sur le développement de l'innervation des paraganglions: paraganglion aorticum supracardiale et glomi aortici. *Jour. Méd. de l'Acad. des Sci. de la R. S. S. d'Ukraine*, T. 8, pp. 193-196.
- VINCENT, S. 1910. The chromophil tissues and the adrenal medulla. *Proc. Roy. Soc. London*, Ser. B, vol. 82, pp. 502-515.
- VULPIAN. 1856. Note sur quelques réactions propres à la substance des capsules surrénales. *C. R. Acad. de Sc. de Paris*, T. 43, pp. 663-665.
- WATZKA, M. 1930. Ueber die Verbindungen inkretorischer und neurogener Organe. *Verhandl. d. anat. Gesellsch.*, Bd. 39, S. 185-190.
- WIESEL, J. 1906. Über Erkrankungen der Koronararterien im Verlaufe akuter Infektionskrankheiten. *Wien. klin. Wochenschr.*, 19 Jahrgang, S. 723-725.
- WISLOCKI, G. B. 1922. Note on a modification of the chromaffin reaction, with observations on the occurrence of abdominal chromaffin bodies in various mammals. *Johns-Hopkins Hosp. Bull.*, vol. 33, pp. 359-361.
- , and S. J. CROWE. 1924. Experimental observations on the adrenals and the chromaffin system. *Johns-Hopkins Hosp. Bull.*, vol. 35, pp. 187-193.
- ZUCKERKANDL, E. 1901. Ueber Nebenorgane des Sympathicus in Retroperitonealraum des Menschen. *Anat. Anz.*, Ergänzungsheft., Bd. 19, S. 95-107.

ADDENDUM

Since this was written, the following reviews have appeared:

- HEYMANS, C. and J. J. BOUCKAERT. 1939. Les chémorécepteurs du Sinus Carotidien. *Ergebn. d. Physiol.* Bd. 41, S. 28-55.
- SCHMIDT, C. F. and J. H. COMROE, JR. 1940. Functions of the carotid and aortic bodies. *Physiol. Rev.*, vol. 20, pp. 115-157.





APPLICATION OF HIGH-FREQUENCY ELECTROSTATIC FIELDS IN AGRICULTURE

By P. A. ARK

Division of Plant Pathology, Department of Agriculture, University of California, Berkeley, Calif.

AND

WILLET PARRY

Technician in Electrical Engineering, University of California

INTRODUCTION

IN RECENT years studies on phenomena accompanying an application of high-frequency currents to biologic materials, such as bacteria, insect pests, etc. have been made. The term "a high-frequency-electrostatic-field" refers to the field between two electrodes of some form which is subject to a periodic charge and discharge by an oscillating electric circuit.

Physics involved in the phenomenon are extremely complex. Matter is considered, in the light of modern physics, as made up of electricity or conversely, that electricity is the fundamental basis of matter. Any kind of matter, a book, a table, or a living body, is, in the final analyses, an assemblage of electrons and protons associated with a quantity of energy proportional to the mass of the body. Furthermore, every particle of matter in constant vibration has a definite frequency. Biologists are always eager to test the effect of various physical factors on biologic material whenever that factor is subject to laboratory handling. Thus, much work has already been done on the action of various types of radiant energy such as gamma, X- and Roentgen rays (1, 13, 20, 22, 50, 55, 61, 81, 167, 168, 169, 170, 171, 172, 182, 222, 227), radium emanation (111, 112, 175,

176, 179), ultra-violet rays, visible light spectrum and infra-red light (46, 50, 57) on living things.

Studies of the so-called ultra-sonic waves, in relation to the effect of that type of radiation on living matter, have yielded very interesting results (15, 19, 29, 30, 31, 47, 48, 65, 66, 67, 68, 69, 70, 71, 79, 94, 117, 147, 154, 155, 166, 186, 198, 199, 200, 208, 216, 228, 229, 230, 231, 232, 233). An application of this type of energy was recently made (85) to increase the yield of potato and pea crops. An average increase of 16.7 per cent in yield was observed on potato tubers sonized by 4×10^8 cycles per second. Pea seeds treated by ultra-sonic waves showed increased germination, earlier blooming, and were noticeably more vigorous than the controls. Although the peroxidase activity increased, the activity of catalase decreased as a result of applying ultra-sonic waves.

Recently biologists have become interested in the type of radiation used in radio transmission, commonly known as Hertzian waves. This includes long, short, and ultra-short radio waves. The short and ultra-short radio waves are situated between the extreme infra-red and long radio waves in the electro-magnetic spectrum. It is customary to classify radio waves as long when they range from 200 meters or more, as short when they are

from 10 meters to 200 and from 10 down as ultra-short.

With the improvement of the short-wave-vacuum-tube-radio-oscillator for ob-

The equipment now used by investigators is constructed on the principle of a short-wave radio transmitter in which the output of the oscillating tubes is concen-

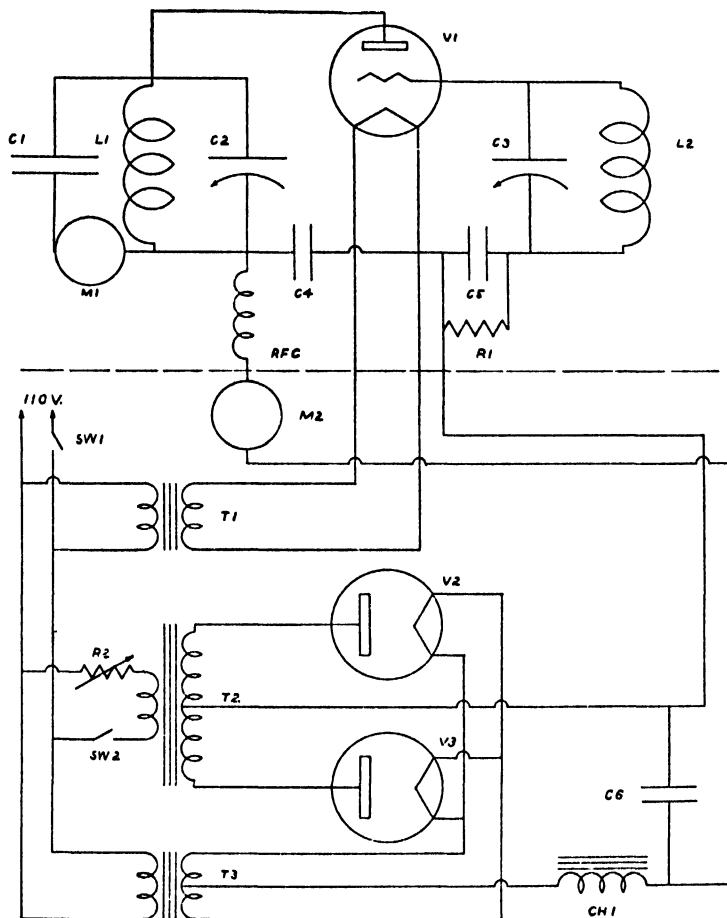


FIG. 1. THE HIGH-FREQUENCY GENERATOR AND POWER SUPPLY

- | | | | |
|----|---|-----|---------------------------------------|
| C1 | Exposure condenser, consisting of two aluminum plates | M1 | Thermo-couple radio-frequency ammeter |
| C2 | Variable condenser (transmitting type) | M2 | Milliammeter dc |
| C3 | Variable condenser (receiving type) | T1 | Power transformer |
| C4 | Fixed condenser | T2 | Filament transformer |
| C5 | Fixed condenser | T3 | Filament transformer |
| C6 | Filter condenser | CH1 | Smoother choke |
| R1 | Resistor | SW1 | Filament and main line switch |
| R2 | Variable resistor | SW2 | High voltage power switch |
| | | V1 | Type 852 (RCA) |

taining high-frequency waves, it soon became possible to utilize high-frequency electrostatic fields in biological research (40, 123, 125, 157, 162, 163, 180, 221).

trated between two aluminum or copper plates coupled to the oscillating circuit of an oscillating tube (Fig. 1).

In 1893, d'Arsonval (7, 8) observed a

rise in temperature and increased metabolism in small laboratory animals when they were exposed to high-frequency currents. Later he and his assistants (9, 10, 11) reported additional observations on biologic changes induced in bacteria and toxins by a current oscillating at a rate of 800,000 c.p.s.

Although d'Arsonval's discovery of the thermal effect of frequency currents led to the development of diathermy, he and his collaborators' observations on the behavior of bacteria and the diphtheria toxin, when high-frequency currents are applied to them, were not followed up. Thus the idea of a possible use of this type of energy in medicine and biology at large lay dormant until 1924, when Gosset, Gutermann, Lakhovsky and Magrou (59) claimed to have destroyed crown gall tumors in geranium plants by the use of electro-magnetic waves of frequency 150,000,000 c.p.s. (2 meters). Unfortunately, the report does not contain a description of the apparatus used, nor does it mention whether or not there was any change in temperature in the treated tumors. Later workers failed to corroborate Gosset's work (173, 209, 210). Soon a type of apparatus suitable for laboratory experimentation with living material became available. This led to numerous, important discoveries so that radio-frequency currents are now used in biological and chemical research, medicine, and to some extent in agriculture (32, 34, 40, 141, 146, 196).

The purpose of this paper is to review most of the literature pertaining to the effects of high-frequency oscillating fields.

EFFECT OF OSCILLATING ELECTROSTATIC FIELDS ON MEN AND ANIMALS

Small laboratory animals and men exposed to high-frequency field were found to respond to it by rise of body tempera-

ture. Thus, Schereschewsky (187, 190) noticed that temperature of mice increased when they were placed between the plates (electrodes), particularly at certain frequencies. In his experiments he observed irregularity in the effects of different frequencies on lethality to mice. His work (190) on therapeutic effects of high-frequency currents on mouse sarcoma and Rous fowl sarcoma is very interesting. The optimum frequency in the case of these sarcomas was between 66 and 68 megacycles per second. A frequency of 135 mg.p.s. was found to be entirely ineffective. Dickens, *et al.* (38, 39) obtained similar results with sarcoma. Baldwin and Nelson (14) observed profound histological changes in albino rats after exposure to high-frequency currents. Kahler, Chalkley and Voegtlin (97) killed *Paramoecium caudatum* with a short exposure in a high-frequency oscillating field and concluded that this was purely a thermal effect, since they could also be killed by hot-water treatment of like duration. Carpenter and Boak (24) were able to markedly arrest or inhibit development of experimental syphilis in rabbits. They used a wave-length of 30 meters and 0.35 amperes in a secondary tank circuit.

Artificial production of fever in man can easily be accomplished by means of ultra-short-wave currents and is employed as a therapeutic means, as shown by Carpenter, Boak and Page (25). Graham and Fabian (62) studied the effect of high-frequency currents on many different animal species (cf. Table 1).

EFFECT ON INSECTS

The effect produced by high-frequency currents on insects is obviously of great economic importance. Studies on this subject conducted since 1929 indicate that Hertzian waves can be and actually are

utilized in eliminating such pests as bean weevils and flour moths.

Headlee (73, 74, 75, 76, 77, 78) has studied the effect of high-frequency currents on insects since 1928. In his experiments Headlee used a Hartley type of circuit (77), testing frequencies from 750,000 to 14,000,000 c.p.s. Insects (in a test tube) were placed between two aluminum plates of the exposure condenser for time intervals. Insects were warm to the touch after they had been killed in an electrostatic field. He concluded that death was caused by exposure to a lethal

the second case the temperature was correspondingly higher, and therefore, grubs died sooner. Headlee (73, 76) tested the effect of radiation, which had proved lethal to insects, on plants by subjecting wheat seeds and wheat seedlings to an electrostatic field oscillating 750,000 to 14,778,000 c.p.s. He found that wheat seed germinated normally under 3,000,000 c.p.s. for 80 minutes while seedlings were uninjured up to a 10-minute exposure, conditions being the same in both cases.

McKinley (122) subjected parasitic wasps, *Habrobracon juglandis*, of different

TABLE 1

The influence of displacement current of different frequencies on various species of animals

NAME OF ANIMAL	FREQUENCY		
	10 mg.p.s.	15 mg.p.s.	7.5 mg.p.s.
<i>Mus musculus</i>	2'09"	31'03"	45'*
<i>Passer domesticus</i>	1'20"	17'40"	45'*
<i>Perca flavescens</i>	12'44"	45'*	45'*
<i>Cambarus americanus</i>	3'26"	28'30"	45'*
<i>Thamnophis sirtalis</i>	2'19"	25'36"	45'*
<i>Musca domestica</i>	6'51"	45'*	45'*
<i>Melanoplus femur-rubrum</i>	5'29"	45'*	45'*
<i>Aphis mellifica</i>	1'29"	45'*	45'*
<i>Samia cecropia</i>	killed instantly	killed instantly	killed instantly
<i>Anosia plexippus</i>	killed instantly	killed instantly	killed instantly
<i>Lumbricus terrestris</i>	2'24"	26'36"	45'*
<i>Rana virescens</i>	3'20"	34'39"	45'*
<i>Ambystoma tigrinum</i>	32.5"	20'36.6"	45'*
<i>Graptomys geographica</i>	did not kill in 1 hour	did not kill in 1 hour	did not kill in 1 hour

* Did not kill.

temperature. He subjected grubs of the Japanese beetle to an oscillating current of 3,000,000 c.p.s., with voltage gradients between plates 4,000 $\frac{\text{volt}}{\text{inch}}$ and 5985 $\frac{\text{volt}}{\text{inch}}$.

[Voltage gradient is determined by the formula $V \left(\frac{\text{volt}}{\text{cm.}} \right) = \frac{6000 \times I \times \lambda}{S^2}$ (35),

where I is in amperes, λ in meters, and S in centimeters and is the area of the condenser plates]. Grubs died in 90 to 180 seconds with the first gradient and in 60 to 120 seconds with the second gradient. Because of the higher voltage gradient in

age, sex, and condition of feeding to a frequency current tuned to 3.5 meters and having 1.8 amperes in the auxilliary circuit. The wasps were killed in an average time of 11.41 seconds. In another experiment (121), he determined that the lethal time for Golden Bantam corn was from 5 to 60 minutes. Corn seeds exposed for from 30 to 40 seconds were definitely stimulated. Hadjinicolau (64) was successful in killing adults, larvae and pupae of insects feeding on stored products. Larvae of *Plodia interpunctella* affecting dry figs, apricots, etc., and larvae and pupae of

Sitrodrejea panicea affecting ground pepper were killed when irradiated for a period of time ranging from 2 to 2.5 minutes, frequency being 1,090,000 c.p.s. and a field strength of $3,977.6 \frac{\text{volt}}{\text{inch}}$. All stages of the bean weevil are killed, without harming the seed, with a field strength of $4000 \frac{\text{volt}}{\text{inch}}$. Vishniakova (226) found that humidity of the seed is an important factor in lethality of high-frequency currents. Temperature of the seed fluctuated from 33 to 66°C., depending upon wavelength, voltage gradient, and water content, when a lethal dose was employed. From her experiments she concluded that the most useful wave-length of any condition of seed is six meters. She also found that lethal time for pupae and adults of the bean weevil was the same, while larvae and eggs required longer exposures. Thus, with a voltage gradient of $5080 \frac{\text{volt}}{\text{cm}^2}$, they perished in 18 seconds, while with a gradient of $7000 \frac{\text{volt}}{\text{cm}^2}$ it requires 6 to 8 seconds. Mites are more resistant than weevils. They require higher gradients and longer exposures. With a voltage gradient $8000 \frac{\text{volt}}{\text{cm}^2}$ and a wave-length of 5 meters they perished in 2 minutes. Later, however, she found that they were killed with the same exposure as bean weevils when surrounded by seed. Experiments of Vishniakova (226) showed that the fall in germination for any voltage gradient depends on the time of exposure and it requires longer exposures than those for killing insects. A fall in germination coincides with a temperature of 50° to 60°C. within exposed seed. The killing time for insects was considerably lower when they were exposed in a layer from 1.5 to 3 cms. thick.

Andreiev and Balkashin (3) used apparatus with a range of from 8 to 40 meters, with a field strength of 3500 volts in a primary circuit, and with plates 12 cms. x 15 cms. separated 2.5 cms. Their material consisted of wheat seed and the following mites: *Aleurodus farinae* Degeer., *Glyciphagus cadaverum* Schr., *Tyroglyphus longior*, and *Cheriletus eruditus*. Wheat seeds weighing 40 grams and artificially infested with the mites were placed in small paper troughs (6 cms. x 3 cms.). After each exposure, the seeds were examined, and from each lot was taken a sample of 200 seeds in order to determine the effect of treatment on germination. The remaining seeds were placed in both a dry jar and a jar with moist filter paper and observed for four days. Two controls were included in each test: one in which wheat infested with mites was placed in a dry jar, and the other, in which infested wheat was placed on slightly moistened filter paper in jars. It was observed that the temperature of irradiated seed registered 40° to 70°C., and, in some cases, even higher. The mites were killed in a shorter time under a shorter wave. Under a wave-length of 40 meters mites were killed in 5 minutes, while below 11 meters, they perished in 30 seconds. When seeds were exposed for 1 to 2 minutes, germination was considerably lower. Short exposures (from 15 to 25 seconds) did not seriously affect the seed. It is concluded that insects may be killed in a fraction of a second if the field strength is increased.

Very interesting dependence of lethal dosage on voltage gradient and wave-length is presented by Evreinov (42, 43). All the stages of bean weevil and mites were killed with voltage gradients ranging from 5000 to $7000 \frac{\text{volt}}{\text{cm}^2}$ and wave-lengths from 5 to 7 meters in from 4.8 to

6 seconds. The temperature of the seeds was below 50°C. At a wave-length of 5 meters and a voltage gradient of 6500 $\frac{\text{volt}}{\text{cm}^2}$ (at 53°C.), the lethal time for bean weevils was 2.4 seconds. Lethal action for weevils begins at a voltage gradient of 2000 to 3000 $\frac{\text{volt}}{\text{cm}^2}$. Below a voltage gradient of 2000 $\frac{\text{volt}}{\text{cm}^2}$, the time of exposure may be increased as long as desired without injuring bean weevils. Evreinov and other investigators maintained that the shorter the wave-length, the shorter the lethal time. A small change in a voltage gradient leads to considerable change in an exposure time. If a voltage gradient between 2000 to 3000 $\frac{\text{volt}}{\text{cm}^2}$ is changed approximately 20 to 25 per cent, a lethal dose may change some 200 to 300 per cent. A lethal dose falls rapidly with an increase in thickness of the exposed seed. Moisture content of seed changes a lethal dose and affects the characteristics of apparatus.

In 1933, Davis (34) published a semi-popular account of his investigations on the effect on some materials of 30 and 6 meter wave-lengths from a 20 kilowatt generator. He stated that the 30 meter low-capacity waves were effective in exterminating adult insects in small quantities of wheat within a period of about 90 seconds, but later the eggs hatched. With the 20 kilowatt and 6 meter waves, an exposure of 6 seconds proved lethal to eggs, larvae and adults. His observations on treated materials extended over a period of several months. He observed no injury to the seed. In some cases, an increase in the germinating power of seed (stimulation) occurred.

EFFECT OF AN OSCILLATING ELECTROSTATIC FIELD ON BACTERIA AND FUNGI

The action of electrostatic fields induced by high, or ultra-high, frequencies on bacteria, fungi, and toxins is of considerable interest. As has already been mentioned, d'Arsonval *et al.* noticed some changes in bacteria and diphtheria toxin as early as 1893.

In 1930, Mellon, Szymanowski and Hicks (142) studied the effects of oscillating currents on diphtheria toxin when the temperature-induced effect on material was eliminated. In order to maintain a low temperature level, the toxin was chilled to 7°C., and subsequently treated for 4 minutes with a current until the sum total of minutes of exposure varied from 15 to 60. Control samples were given alternate treatments with ice and hot water at comparable exposures. In another experiment on cooling, a benzol cooler was used. In both tests they reported a definite attenuation of diphtheria toxin, while the temperature attained in the control samples did not affect the toxin.

Haase and Schliephake (63), working with tubercle bacillus (*B. tuberculosis*) and *Staphylococcus* sp., noticed that *B. tuberculosis* treated for 30 seconds by high-frequency currents showed retardation of growth from 14 to 24 days after sub-culturing and staphylococci died more quickly than control cultures similarly exposed in a water bath. With a somewhat complicated arrangement for cooling biologic material undergoing high-frequency current treatments (plate circuit 3000 volts d.c., wave-length from 1.9 to 3.7 meters, and voltage across the plates from 200 to 300 volts) Szymanowsky and Hicks (215) obtained a definite attenuation of the three major bacterial toxins, diphtheria, tetanus, and botulinus in raw broth filtrates. The temperatures ob-

tained in treated solutions did not cause any change in the toxins.

Bacteria can be killed by high-frequency currents, depending upon conditions of the experiment. Fabian and Graham (44), placing bacteria (*B. coli*) in a line of force of high-frequency electrostatic fields found that with a displacement current of 0.8 amperes (secondary winding of transformer delivered 2000 volts) at a frequency of 7.5 mg.p.s., bacteria increased very rapidly. After 10 minutes' treatment the temperature effect was noticeable. At 10 mg.p.s. the temperature began to rise quickly and the number of organisms rapidly decreased. This frequency appeared to be the most effective in killing bacteria. When the temperature of the broth containing bacteria was maintained between 17° and 19°C., "a frequency of 10 mg.p.s. is the most effective in killing bacteria, with 15 megacycles per second the second most effective, and 7.5 megacycles per second the least effective."

Tverskoi (223) studied the behavior of *Erwinia carotovora* in high-frequency electrostatic fields. He suspended the bacteria in a 0.01 per cent NaCl solution and then placed them between condenser plates having a circuit tuned to 15.5 and 10 meters. After this treatment the slanted agar medium was inoculated and incubated at 28° to 30°C. Under conditions of the experiment, it appeared that a wave-length of 10.4 meters was most effective. The growth of the organism was retarded after 2 minutes of treatment, while killing occurred in 2.5 to 3 minutes. He showed that density of the suspension and the time factor were independent as related to killing of the organisms. Bacteria on a glass slide were inhibited in growth after treatment at 5.6 meters for 2 minutes and were dead after 5 minutes. However, bacteria on a dried silk thread

were not killed even after 30 minutes exposure.

Extremely short waves (27 to 45 cms.) have recently been tried on bacteria and fungi by Gier (57). Bacteria (*Pb. vesicatorium*) were killed at the frequency of 35 cms. when exposed for 24 hours or longer. No effect was observed with other wave-lengths on *Actinomyces scabies*, *Saccharomyces* spp., *Alternaria solani*, *Cephalosporium* sp., *Diplodia zeae*, and *Gibberella saubinetii*. Species of *Collybdia dryophila* Fr., *Sclerotium bataticola* Taub., and *Fusarium batatis* Wr. were used by Johnson (95) in his work on the effect of Hertzian waves on fungi. His apparatus was not described although he mentioned the wave-lengths employed (50 and 100 meters). In his words, "there was no effect on 3 and 4 day cultures of *Fusarium batatis*, on 4 to 8 day cultures of *Collybdia dryophila*, on 3 to 4 day old cultures of *Sclerotinia bataticola* as a result of constant irradiation for 65 hours by a wave-length of 100 m. and for 48 hours by a wave-length of 50 m."

Tverskoi (223, 224) found that wave-lengths of 20 and 30 meters were unsatisfactory even with very long exposures. Irradiation with 10.4 meters and less was effective. *Fusarium solani*, *Sclerotinia libertiana*, *Botrytis cinerea* and *Phytophthora infestans* were tested with wave-lengths of 5.6 to 10.4 meters. The effect on fungi began at 10.4 meters, but longer exposures were required. Thus, *F. solani* was inhibited in growth after 10 minutes' exposure. With an increase in field strength, the inhibition time was shortened. For instance, when the distance between the plates was 2.5 cms. instead of 3 cms. at 9 meters wave-length, inhibition for growth of *F. solani* began after 5 minutes' treatment; after 10 minutes the organism was killed. The most effective wave-length appeared to be 5.6 meters.

A one-minute treatment inhibited fungus growth, while exposures from 4 to 6 minutes were lethal. Suspensions of sporangia of *Phytophthora infestans* in saline solution were inhibited after two minutes' treatment between the condenser plates at a temperature of 31° C. and were killed after 3 minutes or more at temperatures of 37° to 41° C. Tverskoi subjected fungi to treatment in a water bath with temperatures corresponding to those obtained between the condenser plates. When *Fusarium solani* was immersed in a water bath at 45° C. and held for 10.5 minutes, there was no effect. However, a temperature of 50° C. for 30 minutes was lethal to the fungus. Yet, in a high-frequency electrostatic field, fungi were killed in 5 minutes when the temperature of the medium reached 50° C.

Wood destroying fungi, *Merulius lacrymans* Schm. and *Poria vaporaria* Pers., were found to be susceptible to ultra-short waves. Imshenetzki (84) found that these fungi may be killed in 45 to 60 minutes in a comparatively weak electrostatic field. He used a generator of 500 watt dissipation, 3000 volts on anode, and 4.2 to 4.8 amperes in a secondary tank circuit. Power between the plates was equal to $504 \cdot 10^8$ ergs. Cultures were irradiated 4 and sometimes 8 meters. The time of exposure varied from 1 to 92 minutes. Experiments were first made with pure cultures and then with wood parasitized by these fungi. Pure cultures of fungi were killed after 60 minutes in a field of 500 volts. *Merulius lacrymans* was killed in 30 minutes. When the strength of a field was 50 volts the fungi could not be killed even after a 2-hour exposure. It was found that wood does not hinder ultra-short waves and that fungi in wood may be killed in from 45 to 60 minutes. Shorter waves shorten the lethal dose: *Merulius lacrymans*, under a wave-length of

8 meters, was killed in 60 minutes, while under 4.5 meters a lethal dose was 50 minutes when the fungus was within or on the surface of wood. The position of a wooden block in a condenser does not affect the sterilizing action of ultra-short waves.

Interesting behavior in a high-frequency electrostatic field was reported by Metlitzky and Soboleva (143) for *Sclerotinia libertiana* and *Botrytis cinerea*. Exposed between plates of 12 cms. diameter, field strength 2000 volts, 5.5 amperes in a secondary tank circuit, and a wave-length of 2.2 meters, these fungi were unaffected by exposures from 1 second to 30 minutes. However, by a wave-length of 5.6 meters they were killed in 20 to 25 seconds. Fungi were inoculated into agar media before treatment. At 45° C., the agar commenced to melt when in the condenser during the treatment, but in a water bath, melting begins only after a temperature of 80° C. has been reached. Lethal effects of the above-mentioned frequencies began when the temperature of the medium registered 30° to 40° C.—temperatures that are not lethal under ordinary conditions.

EFFECT OF OSCILLATING ELECTROSTATIC FIELDS ON PLANTS AND PLANT PARTS

Lakhovsky (105-109), who was the first to study the effect of ultra-short radiation on plant-tumor tissue, noted no ill effects of high-frequency currents on geranium plants. Later workers investigating the effect of high-frequency electrostatic fields on seeds reported under some conditions a definite stimulation of germination. Headlee (76), working with frequencies from 750,000 c.p.s. to 14,778,000 c.p.s., observed no injury to wheat seeds when employing frequencies of 700,000 c.p.s. to 3,000,000 c.p.s., even at 80 minutes' exposure. Seeds exposed

at 5,000,000 c.p.s. for 10 minutes were reduced in germination to 54 per cent at 160° F., as compared with 88.6 per cent germination of the checks. This shows a marked differential between lethality for a host and a pest, since insects are killed sooner.

McKinley (121) exposed seeds of Golden Bantam corn to a frequency current, varying from 5 minutes to an hour. Seeds were killed at these exposures. With a one-minute exposure seeds were not killed but slightly retarded in germination, while "from 30 to 40 seconds, the growth of the seedlings was accelerated in the early germination period."

TABLE 2

Effect of high-frequency electrostatic field (hfe) on germination of carrot and onion seeds (Wave-length 5.7 m.)

SEED	CHECK	5 SEC.	10 SEC.	15 SEC.
	Per cent germination			
Carrot.....	32	63	42	36
Onion.....	30	82	80	69

Bean seeds exposed to an oscillating current in a field strength of 3977.6 volts and a frequency of 1,090,000 c.p.s. did not lose their germinating power while this exposure proved lethal to bean weevils, according to Hadjinicolaou (64).

Vishniakova (226) found that at all voltage gradients a longer exposure was required to cause a decrease in germination of seeds than was necessary to kill insects. When seeds are between the plates the temperature of wheat seeds at which a marked decrease in germination was observed lies between 50 and 60° C. Siniuk (205) studied seeds which were aged and low in germination. With an apparatus having a field strength of 3000 volts, 8 amperes in a secondary circuit, with plates 8 cms. in diameter (separated 50 mm.),

and tuned to 5.7 meters, he found that 2 seconds exposure increased the germination of onion, carrot, and wheat seeds (Table 2).

Currents of a circuit tuned to 11 meters decreased the germination of wheat seeds about 68 per cent when they were exposed for 1.5 minutes. Less damage occurred at 1 minute and practically no injury from 30 seconds or less, according to Andreiv and Balkashin (3).

Some chemical changes occurring in seed during the treatment between condenser plates of the oscillator were reported by Frolov (51). These changes are: decrease in starch, increase in sugar (probably invert sugar), and changes in albumin. An increase in germination and the energy of germination (energy of germination refers to the percentage of seeds which germinated three days after seeds were placed in a germinator) were noticed. Kuperman (103) investigated the effect of high-frequency currents tuned to 7 to 8 meters with a voltage gradient $1200 \frac{\text{volt}}{\text{cm}^2}$ on yield, weight, and

general growth of cucumbers, tomato, and cotton seed. Cucumbers treated for 10 seconds showed an average increase in yield from 473 grams to 584 grams per plant, as well as an increase in dry weight of the plants. Seeds treated for 20 seconds (volt grad. $1000 \frac{\text{volt}}{\text{cm}^2}$) and 5 seconds (volt grad. $1200 \frac{\text{volt}}{\text{cm}^2}$) gave plants which began to bear fruit 9 days earlier than the checks. Tomato seeds exposed for 5 to 10 seconds (volt grad. $1200 \frac{\text{volt}}{\text{cm}^2}$) began to fruit 11 days earlier than the checks. The number of fruits on tomato plants from treated seed was 118 to 134 per cent as compared with the controls. Cotton seeds treated for 2 to 5 seconds at a

voltage gradient of $316 \frac{\text{volt}}{\text{cm}}$ gave plants that formed flower buds 8 to 10 days earlier than the checks, and buds opened 27 days earlier. The relation of moisture content of seed to heating when seeds are treated was discussed by Sharoiko (203). Interesting data were presented by Pospelov, Zhilenkov, Burnatzky and Buromsky (161) on treating milo seeds contaminated with smut spores and on stimulation of germination in oats, wheat, and milo. Energy of germination was the best in all three cases when seeds were rayed in a field tuned to 7 meters and exposed for 5 seconds. An increase in energy of germination occurred at 5 meters, at 30 seconds exposure. Smut spores on milo seeds treated by a 5 meter wave-length for less than one minute were killed completely, the seeds not being injured in any way. Chemical analyses of wheat seeds treated by a current tuned to 5 meters with an exposure of 30 seconds are shown in Table 3.

These results showed that the percentage of albumin decreases in treated seeds. Increase in peroxidase parallel with an increase in energy of germination and increase in green weight and flowering 5 days earlier than a check was observed by Tarusov (218, 219) for a blue lupin subjected to treatment by high-frequency currents. Increase in peroxidase takes place in dry as well as in moistened seeds and persists long after treatment.

Wheat seeds artificially infected with *Fusarium* sp. gave 97 per cent germination when irradiated by a high-frequency electrostatic current oscillating at a wave-length of 5.6 meters and exposed for one minute; 90 per cent at 2 minutes exposure; 80 per cent at 4 minutes; and 45 per cent at 6 minutes exposure. *Fusarium* sp. died after exposures of 2 minutes and longer. Thus, for example, it may be possible to

disinfect wheat seeds for fungus diseases caused by smuts, *Fusarium* and *Helminthosporium* sp., etc., concludes Tverskoi.

High-frequency currents are capable of inducing some changes in the chromosome apparatus of plant cells. Krajevoj (102) reported a fragmentation of chromatin material of the nucleus, translocations, and the phenomenon of "somatic reduction" when pea seeds were exposed to a high-frequency electrostatic field.

High-frequency electrostatic fields may be used to temporarily inactivate and enhance the enzymatic mechanism of fruits and vegetables, and thus may be of service in storage preservation and ripening of those products (26, 27, 28). Re-

TABLE 3

Albumin content of wheat seeds treated in a high-frequency electrostatic field tuned to 5 meters

	PER CENT OF ALBUMIN
Check (untreated; not germinated)....	14.6
Check (untreated; in germinator 1 day)...	12.3
Check (untreated; in germinator 2 days)...	11.33
Treated (in germinator 1 day).....	9.56
Treated (in germinator 2 days).....	8.59

sults obtained by Cerevitinov and Metlitzky (28) indicate it is possible to prolong keeping time of apples, pears and grapes and to hasten the ripening of green tomatoes. Grapes which were exposed for one minute (8 mg.p.s.) gave, at the end of 23 days of storage, 3.5 times less overripe than those treated 1 second and 10 times less than the controls. There was no decrease in vitamin C content in treated materials. Green tomatoes rayed for one minute ripened 14 days later, while only 62 per cent of the controls ripened (cf. Table 4).

What is the mechanism of action in high-frequency fields? No definite answer to this highly important question can be

given at present. Many theories attempt to explain different phenomena induced by high-frequency currents. The principal explanations are: heat produced as a result of energy absorption by the treated material (conduction currents); resonance theory; effect of dipoles, and specific effect. Detailed information on these topics is contained in certain papers (4, 21, 24, 35, 36, 38, 39, 40, 45, 52, 74, 75, 77, 80, 97, 98, 100, 110, 113, 114, 115, 126, 127, 128, 134, 137, 138, 140, 142, 153, 156, 157, 158, 187-190, 191-197, 204, 206, 215, 220).

ECONOMICS OF HIGH-FREQUENCY TREATMENT

Mouromtseff (146) stated that irrespective of the conditions, the safe mini-

seeds from insect pests, smuts, and increasing yields of various crops. As a result of this intensive work (141,219) 92 hectares of truck crops, oil-yielding plants, etc. were planted in 1935 with rayed seeds. These were orientation tests in order to determine the best dosage for seeds under different conditions. In 1936, sufficient seeds were rayed to plant: 7232 hectares of cotton, 4000 hectares of corn, 1100 hectares of castor bean, and 100 hectares of vegetables. The results were as follows:—Cotton, an increase in yield from 0.3 to 4 centners per hectare (1 hectare equals 2.5 acres; 1 centner equals 220 pounds); castor bean, an average increase of 1.05 centners per hectare, or about 17 per cent.

TABLE 4

Effect of high-frequency oscillating fields on tomatoes (after Cerevitinov and Maslirski (28))

NO.	DURATION OF IRRADIATION	CONDITION OF TOMATOES AFTER 14 DAYS OF STORAGE					
		Flesh colored	Brown	Pink	Red	Culls	Damaged
1	1 second	12.5	25	12.5	50	—	12.5
2	5 seconds	25	25	—	50	—	12.5
3	30 seconds	25	12.5	37.5	25	25	12.5
4	1 minute	—	—	12.5	87.5	12.5	—
5	3 minutes	12.5	37.5	12.5	37.5	12.5	—
6	check	12.5	25	12.5	50	12.5	25

imum of energy for 100 per cent kill of weevils was 443 watt-seconds per cubic inch. If we assume 450 watt-seconds of energy per cubic inch then it will give us 970,000 watt-seconds per bushel (450 x 2150) or 0.27 kilowatt-hour per bushel of wheat. If the overall efficiency were 40 per cent, the necessary input will be 0.67 kilowatt-hour per bushel. "From this it can be concluded that the high-frequency treatment of wheat proves to be economically sound," concludes Mourontseff.

Since 1934, 14 scientific institutions in Russia have been engaged in research on possible utilization of ultra-short radio waves in agriculture, i.e. for cleaning

On some farms employing superior methods, the increase amounted to 3 centners per hectare. The yield of vegetables increased from 70 to 80 per cent. The potato yield increased 100 per cent, and the sunflower crop from 50 to 60 per cent (controls, 15.4 $\frac{\text{centr.}}{\text{hect.}}$; treated, 23 $\frac{\text{centr.}}{\text{hect.}}$ or an increase of 7 $\frac{\text{centr.}}{\text{hect.}}$).

In 1937, Dnepropetrovsk province planned to treat seed enough to plant 240,000 hectares, or 600,000 acres, as follows: cotton, 60,000 hectares; corn, 119 hectares; castor bean, 15,800 hectares; vegetables, 11,315 hectares; watermelons, cantaloupes, etc., 29,310 hectares; pota-

toes, 2950 hectares. At present, Dnepropetrovsk province has about 10 high-frequency treaters (treating stations) using oscillators consisting of 2 tubes of 400 watts, tuned to 7 to 8 meters. The generator capacity is 15 tons per working day of 10 hours, with an average of 3000 pounds per hour.

DISCUSSION

High-frequency electrostatic fields cause some definite changes in biological material. Although the real mechanism by which changes occur in various materials exposed to the action of oscillating electrostatic fields has not been established with certainty, the application of the phenomenon to various problems in biology and in particular to some branches of agricultural science should not be overlooked. Numerous investigations show that insect pests, fungi, and bacteria may be destroyed by heat induced by the passage of electric forces (3, 43, 44, 60, 64, 75, 84, 161, 223, 224, 226). It may be

that only certain vital parts of the living object are heated momentarily to such a degree that death ensues. This is in accord with Malov's theory of "point heat" (134, 137, 138).

Inasmuch as it is both interesting and important to know the underlying causes of the effects of high-frequency electrostatic fields, the value of it is readily grasped when the destructive work of various cereal weevils can be controlled permanently by a simple, inexpensive and non-chemical procedure (34, 146) or when wood-destroying fungi may be destroyed by passing lumber between the plates of oscillating generator (84) thus saving considerably in terms of labor and expense.

These experiments indicate that seed-borne pathogens (bacteria and fungi) may be destroyed on or in the seeds without injuring the latter. It may also be possible to increase the power of germination of seeds whose germination has been lowered appreciably or which are naturally more difficult to germinate.

LIST OF LITERATURE

1. AFANASIEVA, A. S. Deistvie rentgenovikh luchei na elementi kletki iarovoi pshebitsi *Triticum vulgare* var. Caesium O. III. (Action of Roentgen rays on cell elements of *Triticum vulgare* var. Caesium O. III.) *Biologicheskii Zhurnal*, 5 (1): 117-123. 1936.
2. ALIEVA, V. Deistvie ultravisokikh chastot na zhivie organizmi. (Obsor inostrannoi literatury.) (Action of ultra-short waves on living organisms.) (Review of foreign literature.) *Elektrifikatsiia Sel'skogo Khoziaistva*, 4: 82-89. 1935.
3. ANDREIEV, S., and B. BALKASHIN. Toki visokoi chastoty v borbie s muchnimy kleshami. (Application of high-frequency currents to flour-mite control.) *Zashchita Rastenii* (Plant Protection), (1): 121-123. 1935.
4. ARKADIEV, V. K. Quasi-chemical action of Herizian waves and their application. *Compt. Rend. Acad. Sci. U. R. S. S.*, 3: 412-413. 1934.
5. ARNAUDI, C., and G. VENTURELLI. L'azione del radio sui tumori vegetali. *Riv. di Biol.*, 16: 61-80. 1934.
6. D'ARSONVAL, A. Influence de la fréquence sur les effets physiologiques des courants alternatifs. *Compt. Rend. Acad. Sci. (Paris)*, 116: 630-632. 1893.
7. —. L'auto conduction ou nouvelle méthode d'électrisation des êtres vivants: mesure des champs magnétiques de grande fréquence. *Compt. Rend. Acad. Sci. (Paris)*, 117: 34-36. 1893.
8. —. Action physiologique des courants alternatifs à grande fréquence. *Arch. Phys. Normale et Pathologique*, Ser. 5., 5: 401-408. 1893.
9. —, and M. CHARRIN. Action des diverses modalités électriques sur les toxines bactériennes. *Compt. Rend. Soc. Biol.*, 48: 96-99. 1896.
10. —, and —. Action de l'électricité sur les toxines bactériennes. *Compt. Rend. Soc. Biol.*, 48: 121-123. 1896.
11. —, and —. Action de courants induits de haute fréquence sur le bacille pyocyanique. *Compt. Rend. Soc. Biol. (Paris)*, 45: 467-469. 1893.

12. D'ARSONVAL, A. Action biologique des courants de haute fréquence. *Intern. Kong. Electro-Radio-Biol.*, 1: 111-114. 1935.
13. ATABEKOVA, A. I. Deistvie rentgenovikh luchei na semena i proroski gorokha. (Action of Roentgen rays on pea seeds and seedlings.) *Biologicheskii Zhurnal*, 5 (1): 99-115. 1936.
14. BALDWIN, W. M., AND N. G. NELSON. Histological effects produced in albino rats by high-frequency currents. *Proc. Soc. Exp. Biol. and Med.*, 26: 588-590. 1929.
15. BECKWITH, T. D., AND A. R. OLSON. Ultra-sonic radiation and yeast cells. *Proc. Soc. Exp. Biol. and Med.*, 29: 362-364. 1932.
16. BENEDETTI, E. Intorno all'azione del campo elettro-magnetico oscillante ad alta frequenza su alcuni germi vegetali. *Atti R. Accad. Naz. Lincei Rend. Cl. Sci. Fis. Mat. et Nat.*, 4(7/8): 324-332. 1926.
17. ——. Su alcune modificazioni del decorso della fermentazione alcoolica per effetto del campo elettro-magnetico oscillante sul lievito. *Rend. R. Accad. Lincei, Ser. 6.*, 5(12): 1029-1034. 1927.
18. BESSEMAN, A. AND L. ASHERT. Influence de divers agents physiques sur un sarcome Ehrlich de la souris. *Ann. Inst. Pasteur*, 57: 516-525. 1936.
19. BIANCANI, E., H. BIANCANI, AND A. DOGNON. Les ultra-sons et leurs actions biologiques. *Jour. Physiol. et Path. Gen.*, 32(4): 1083-1106. 1934.
20. BLESS, A. A. Effects of the length of X-ray waves on seeds. *Proc. Nat. Acad. Sci.*, 23: 194-196. 1937.
21. BOAK, RUTH A., CHARLES M. CARPENTER, AND STAFFORD L. WARREN. I. Studies on the physiological effects of fever temperatures. II. The effect of repeated short-wave (30 meter) fevers on growth and fertility of rabbits. *Jour. Exp. Med.*, 56: 725-739. 1932.
22. BRESLAVETZ, L. P., AND A. S. AFANASIEVA. The action of X-rays on the rye. II. X-radiation of seeds. *Cytologia (Tokyo)*, 8(1): 110-127. 1937.
23. CARANDO, QUIRICO, AND ENZO DELARENZI. Influenza di onde corte hertziane sulla vitalità della colture in vitro dei tessuti. *Boll. Soc. Ital. Biol. Sper.*, 10: 701-702. 1935.
24. CARPENTER, C. M., AND A. F. BOAK. The effect of heat produced by an ultra-high-frequency oscillator on experimental syphilis in rabbits. *Amer. Jour. Syphilis*, 14(3): 346-364. 1930.
25. —, —, AND A. B. PAGE. The production of fever in man by short radio waves. *Science*, 71 (1844): 450-452. 1930.
26. CEREVITINOV, S. Priminenie U K V. (Application of ultra-short waves.) *Radiofront*, 2: 157. 1931.
27. CEREVITINOV, S. F. (A brief communication on short radio waves in application to agriculture.) *Elektrifikatsia Selskogo Khoziaistva*, 1: 45. 1935.
28. —, AND L. V. METLIZKIY. Deistvie elektricheskago polia visokoi chastoti na khranenie i dozrevanie plodov i ovoschei. (The effect of an electric field of high-frequency on keeping qualities and ripening of fruits and vegetables.) *Compt. Rend. Acad. Sci. U. R. S. S.*, 8/9: 588-593. 1935.
29. CHAMBERS, L. A., AND E. N. HARVEY. Some histological effects of ultra-sonic waves on cells and tissues of the fish *Lebistes reticulatus* and on the larva of *Rana silvatica*. *Jour. Morph. and Physiol.*, 52: 155-164. 1931.
30. —, AND NEWTON GAINES. Some effects of intense audible sound on living organisms and cells. *Jour. Cell. and Comp. Physiol.*, 1: 451-471. 1932.
31. —, AND EARL W. FLASDORF. The denaturation of protein by sound waves of audible frequencies. *Jour. Biol. Chem.*, 114: 75-84. 1936.
32. DE CHOLNOKY, T. Short wave diathermy. Columbia University Press, 1927.
33. CHRISTIE, R. V., AND A. L. LOOMIS. The relation of frequency to the physiological effects of ultra-high-frequency currents. *Jour. Exp. Med.*, 49(2): 303-321. 1929.
34. DAVIS, J. H. Radio waves to kill insect pests. *Scientific American*, 148(5): 272-273. 1933.
35. DEBYE, P., AND H. FALKENBERGEN. Dispersion von Leitfähigkeit und Dielektrizitätskonstante bei starker Elektrolyten. *Physik. Zeitschr.*, 29(5): 121-132. 1928.
36. —, AND —. Dispersion der Leitfähigkeit und der Dielektrizitätskonstante bei starker Elektrolyte. *Physik. Zeitschr.*, 29(13): 401-426. 1928.
37. DENIER, A. Action biologique des ondes hertziennes ultracourtes de 80 centimètres. *Arch. d'Electric. Méd.*, 41: 273-276. 1933.
38. DICKENS, FRANK, STANLEY F. EVANS, AND HANS WEIL-MALHERBE. The action of short radio waves on tissues: I. Effects produced in vitro. *Amer. Jour. Cancer*, 28: 603-620. 1936.
39. —, —, AND —. The action of short radio waves on tissues. II. Treatment of animal tumours in vivo. *Amer. Jour. Cancer*, 30: 341-354. 1937.
40. DUGGAR, BENJAMIN M. Biochemical Effects of radiation. Vols. 1 and 2. McGraw-Hill

- Book Company, Inc., pp. 1342. N. Y.—London. 1936.
41. ESAU, A. Versuche mit kurzen electrischen Wellen. *Electrotechnische Zeitschr.*, 47: 1, 321. 1926.
 42. EVREINOV, M. G. Elektrichestvo kak factor organicheskikh processov. (Electricity as factor of organic processes.) *Elektrifikatsiia Selskogo Khoziaistva*, 5: 3-12. 1934.
 43. —. Deistvie U K V na nasekomikh i semion. (Action of ultra-short waves on insects and seeds.) *Elektrifikatsiia Selskogo Khoziaistva*, 1: 20-29. 1935.
 44. FABIAN, F. W., and H. T. GRAHAM. The influence of high-frequency displacement current on bacteria. *Jour. Inf. Dis.*, 53: 76-88. 1933.
 45. FABRY, CH. Sur le calcul de la chaleur dégagée par les courants de haute fréquence. *Compt. Rend. Acad. Sci. (Paris)*, 185: 684-687. 1927.
 46. FEMHOTT, L. O deistvii radiovoln i ultrafioletovikh luchei na nasekomikh. (Action of radio waves and ultra-violet rays on insects.) *Zashchita Rastenii (Plant Protection)*, 6: 147-158. 1935.
 47. FLOREDORE, EARL W., and LESLIE A. CHAMBERS. The chemical action of audible sound. *Jour. Amer. Chem. Soc.*, 55: 3051-3052. 1933.
 48. —, and —. An immunological study of the effects of internal sound variations on egg albumin. *Jour. Immunol.*, 28: 297-310. 1935.
 49. FREUNDLICH, H., K. SÖLLNER, and F. ROGOWSKI. Einige biologische Wirkungen von Ultraschallwellen. *Klin. Wochenschr.*, 36: 1512-1513. 1932.
 50. FROLOV, G. Deistvie rentgenovskikh i ultrafioletovikh luchei na rastenii. (Action of X-rays and ultra-violet rays on plants.) *Trudy Selskikh Akad. K. A. Timiriazeva*, 1(3): 189-206. 1936.
 51. FROLOV, M. V. Vliianie polia visokoi chastoty na desinfektsiiu zerna i muky. (Effect of field of high-frequency on sterilization of seed and flour.) *Elektrifikatsiia Selskogo Khoziaistva*, 1: 36-37. 1935.
 52. VON FÜRTH, REINHOLD. Dielektrizitätskonstanten einiger wässriger Lösungen und ihre Deutung nach der Dipoltheorie von Debye. *Annalen der Physik*, 70: 63-80. 1923.
 53. GEBBERT, A. Über die Abhängigkeit der Oberflächen und Tiefenwirkung der Ultrakurzwellenströme von Elektrodenart und Elektrodenabstand. *Klin. Wochenschr.*, 13(25): 905-907. 1934.
 54. —. Der Einfluss der Wellenlänge auf die Wärmeverteilung im Körper bei Ultrakurzwellentherapie. *Klin. Wochenschr.*, 13(44): 1563-1565. 1934.
 55. GEBBERT, FRITZ. Untersuchungen über die wachstumhemmende Wirkung der Röntgenstrahlen. *Biol. Zentralbl.*, 54(11/12): 567-587. 1934.
 56. GHEBOROUI, I. Le cancer expérimental et la théorie de Lakhovsky. *Compt. Rend. Soc. Biol.*, 106: 754-756. 1931.
 57. GIER, L. J. Effects of ultra-short radio waves and ultra-violet light on microorganisms. *Trans. Kansas Acad. Sci.*, 40(1937): 55-57. 1938.
 58. GILBERT, A. Über die Abhängigkeit der Oberflächen und Tiefenwirkung der Ultrakurzwellenströme von Elektrodenart und Elektrodenabstand. *Klin. Wochenschr.*, 13: 905-907. 1934.
 59. GOSSET, A., A. GUTMAN, G. LAKHOVSKY, and I. MAGROU. Essai de thérapeutique du cancer expérimental des plantes. *Compt. Rend. Soc. Biol. (Paris)*, 91: 626-628. 1924.
 60. GOUBAREFF, A. N. The high-frequency oscillator: its design and use in the study of stimulating and lethal effects on certain biological materials. Master of Science Thesis. Univ. of Calif. 1937.
 61. GOWEN, J. W., and W. C. PRICE. Inactivation of tobacco-mosaic virus by X-rays. *Science*, 84: 536-537. 1936.
 62. GRAHAM, H. T., and F. W. FABIAN. A note on the influence of high-frequency alternating current on animals. Rept. Div. Vet. Sci. Mich. State College of Agr. and Appl. Sci. for the year 1935: 50-54. 1935.
 63. HAASE, W., and E. SCHLIEPHAKE. Versuche über den Einfluss kurzer elektrischer Wellen auf das Wachstum von Bakterien. *Strahlentherapie*, 40: 133-158. 1931.
 64. HADJINICOLAOU, J. Effects of certain radio waves on insects affecting certain stored products. *Jour. New York Ent. Soc.*, 39: 145-160. 1931.
 65. HARGOOD, F. L. Ultrasonics: some properties of inaudible sound. *Nature*, 128: 748-751. 1931.
 66. HARVEY, E. NEWTON. The effect of high-frequency sound waves on heart muscle and other irritable tissues. *Am. Jour. Physiol.*, 91: 284-290. 1929.
 67. —. Biological aspects of ultrasonics, a general survey. *Biol. Bull.*, 59: 306-325. 1930.
 68. —, E. B. HARVEY, and S. L. LOOMIS. Further observations on the effects of high-frequency waves on living matter. *Biol. Bull.*, 55: 459-469. 1928.

69. HARVEY, E. N., and A. L. LOOMIS. Biological effects of high-frequency sound waves of small intensity. *Nature*, 121: 622. 1928.
70. —, and —. The destruction of luminous bacteria by high-frequency sound waves. *Jour. Bact.*, 17: 373-376. 1929.
71. —, and —. High speed photomicrography of living cells subjected to supersonic vibrations. *Jour. Gen. Physiol.*, 15: 147-153. 1931.
72. HASCHKE, E., and H. LEUNIG. Ueber die Wirkung von Ultra-kurzwellen auf Bakterien. *Dtsch. Med. Wschr.*, 2: 1193-1195. 1935.
73. HEADLEE, THOMAS J. The differential between the effect of radio waves on insects and on plants. *Jour. Econ. Entom.*, 24(2): 427-437. 1931.
74. —. Further studies of the effects of electromagnetic waves on insects. *Jour. Econ. Entom.*, 25(2): 276-288. 1932.
75. —. The effect of radio waves on the internal temperatures of certain insects. *Jour. Econ. Entom.*, 26(2): 313-319. 1933.
76. —. Some Observations on the Effect of Radio Waves on Insects and Plant Hosts. *New Jersey Agr. Exp. Sta. Bul.* 568. 16p. 1934.
77. —, and R. C. BURDETTE. Some facts relative to the effect of high-frequency radio waves on insect activity. *Jour. N. Y. Ent. Soc.*, 37: 59-64. 1929.
78. —, and D. MANLEY JOBBINS. Further studies of the use of radio waves in insect control. *Jour. Econ. Entom.*, 29(1): 182-187. 1936.
79. HENSCH, A. H., ENOCH KARRER, and ALFRED L. LOOMIS. An attempt to induce mutation in *Drosophila melanogaster* by means of supersonic vibrations. *Amer. Nat.*, 64: 552-559. 1930.
80. HICKS, R. A., and W. T. SZYMANOWSKY. The biologic action of ultra-high-frequency currents. Further studies. *Jour. Inf. Dis.*, 50: 466-472. 1932.
81. DEN HOFD, D. Over de Werking van Harde Röntgenstralen en Gammastralen van Radium. Dissertation for the Doctorate, University of Amsterdam, 1934. (Action of short-wave radiation and gamma rays. Abstracted in *Am. Jour. Cancer*, 28: 805. 1936).
82. HORLACHER, W. R. An attempt to produce mutations by the use of electricity. *Science*, 72: 96-97. 1930.
83. HORMER, HELENE R. Heating effects observed in a high-frequency static field. *Science*, 68: 325-327. 1928.
84. IZHENETSKII, A. A., and E. S. NAZAROVA. O deistvii ultrakorotkikh voln na griby razrushashchie drevesinu (*Marulius lacrymans* Schum. i *Peria vaporaria* Pers.). (The effect of ultra-short waves on wood destroying fungi, *Marulius lacrymans* Schum. and *Peria vaporaria* Pers.) *Izvestia Akademii Nauk SSSR Otdel Mat. i Estestv. Nauk*, Ser. Biol. (*Bull. Acad. Sci. URSS Cl. Sci. Math. and Nat. Sci. Biol.*), 1: 221-230. 1937.
85. ISTOMINA, O., and E. OSTROVSKIY. The effect of ultra-sonic vibrations on plant development. *Compt. Rend. (Doklady) Acad. Sci. URSS*, 2(4): 155-160. 1936.
86. IZAR, G., and S. FAMULARI. Sull'azione biologica delle onde corte. Nota IV. Azione su alcuni germi. *Riforma med.*, 1933: 1489-1490. 1933.
87. —, and PASQUALE MORETTI. Sull'azione biologica delle onde corte. Nota VII. Azione sui fermenti. *Riforma med.*, 1933: 1611. 1933.
88. —, and —. Sull'azione biologica delle onde corte. VIII. Azione sulla formazione delle agglutinine e delle precipitine. *Riforma med.*, 1933: 1771-1772. 1933.
89. —, and —. Ueber die biologische Wirkung der kurzen Wellen. Die Wirkung auf die anorganischen Kolloide. *Klin. Wochenschr.*, 13(21): 771-773. 1934.
90. —, and —. Die Wirkung der kurzen Wellen auf den Verlauf des Maltafiebers. *Klin. Wochenschr.*, 14(2): 46-47. 1935.
91. JELLINEK, S. Effets biologiques des champs oscillants à ondes courtes sur les êtres vivants. *Compt. Rend. Acad. Sci.*, 191: 1030-1032. 1930.
92. —. Biologische Wirkungen der ultrakurzen Wellen. *Wim. klin. Wochenschr.*, 46: 646-650. 1933.
93. —. Biology of ultra-short waves. *Arch. Phys. Therapy*, 17: 512-513. 1936.
94. JOHNSON, C. H. The lethal effect of ultra-sonic radiation. *Jour. Physiol.*, 67: 356-359. 1929.
95. JOHNSON, T. H. Effects of electromagnetic waves on fungi. *Phytopathology*, 22(5): 277-300. 1932.
96. JOLTRAIN, E., D. MORAT, and L. DELHERM. Réactions biochimiques de l'organisme humain sous l'influence des ondes courtes. *Rev. Physiol.*, 12: 114-145. 1936.
97. KAHLER, H., H. W. CHALKLEY and CARL VOGTLIN. The nature of the effect of a high-frequency electric field upon *Paramoecium*. *Public Health Rep.*, 44: 339-347. 1929.
98. KALENDAROV, G. S. Ultrakorotkie volni v biologii i medicine. (Ultra-short waves in biology and medicine.) *Arch. Biol. Sci. (Ser. A)*, 35(x): 113-122. 1934.

99. KOPACKIEWSKI, W. Ondes électromagnétiques et néoplasmes. *Compt. Rend. Soc. Biol.*, 107: 1252-1253. 1931.
100. KOUOUSHEV, A. M. K voprosu o sushchnosti deistvia tokov ultravisokoi chastoti. (On the action of ultra-high-frequency currents.) *Arkhiv Biologicheskikh Nauk (Arch. des Sciences Biologiques)*, 37 (3): 795-813. 1935.
101. KOWARSCHIK, J. Versuche mit Kurzwellendiathermie. *Klin. Wochenschr.*, 12(45): 1757-1763. 1933.
102. KRAVVOI, S. J. Vliianie ultrakorotkikh voln na rasteniia. (The effect of ultra-short waves on plants.) *Izv. Akad. Nauk SSSR, Otdel Mat. i Estestv. Nauk, Ser. Biol. (Bull. Acad. Sci. URSS Cl. Sci. Math. et Nat. Ser. Biol.)*, 1 69-81. 1937.
103. KUFERMAN, F. M. K voprosu o vliianii visokochastotnogo polia (UKV) na uskorenie razvitiia i povisheniia urozhaemosti sel'skokhoziaistvennikh kultur. (On the problem of the effect of high-frequency field on the acceleration of growth and increase of agricultural crops.) *Elektrifikatsiia Sel'skogo Khoziaistva*, 1: 30-36. 1935.
104. LAKHOVSKY, G. L'action sur les êtres vivants des circuits oscillants captant les ondes cosmiques. *Sciences Pures et Appliquées*, 39: 412-414. 1928.
105. —. L'action sur les êtres vivants des circuits oscillants captant les ondes cosmiques. Note. *Compt. Rend. Acad. Sci. (Paris)*, 186: 1019-1021. 1928.
106. —. (Preface par d'Arsonval). Le Secret de la vie. Les Ondes cosmiques et la Radiation vitale. Gauthier-Villars et Cie. 261 p. 23 figs. 6 pl. Paris. 1929.
107. —. Explication des effets thérapeutiques des circuits oscillants ouverts sur l'organisme des êtres vivants. *Compt. Rend. Acad. Sci.*, 188: 657-658. 1929.
108. —. La Science et le Bonheur. Gautier et Villars. Paris. 1930.
109. —. Das Geheimnis des Lebens. Kosmische Wellen und vitale Schwingungen. 264 p. 1931. München.
110. LASAREV, P. Théorie ionique de l'action physiologique des ondes courtes. *Compt. Rend. (Doklady) Acad. Sci. URSS*, III (1): 31-34. 1935.
111. LAVIN, I. and M. LEVINE. The action of buried tubes of radium emanation on neoplasias of plants. *Jour. Cancer Res.*, 7: 163-170. 1922.
112. LAVINE, M. The effects of radium emanation on the crown gall tissue. *Amer. Jour. Roentgenol.*, 14: 221-233. 1925.
113. LIEBENY, PAUL. Kurzwellentherapie. *Wiener. mediz. Wochsch.*, 82(24): 791-795. 1932.
114. —. Ueber wellenspezifische Wirkung der Kurzwellen. *Wien. klin. Wochenschr.*, 46: 799-800. 1933.
115. —. Biologische Wirkungen der Hertzschen Kurzwellen. *Verh. I. Internat. Kongr. Electro-Radio Biol.*, 1: 369-382. 1935.
116. LIPPOLT, HEINRICH and CARL HELLER. Die Einwirkung der Kurzwellen auf Bakterien. *Klin. Wochenschr.*, 13: 1745-1749. 1934.
117. LIU, SZU-CHIH and ALBERT C. H. YEN. Further studies on the effects of supersonic waves on bacteria. *Proc. Soc. Exp. Biol. and Med.*, 32: 485-488. 1934.
118. LUDWIG, FRITZ and JULIUS VON RIES. Wachstumsvorgänge und Hochfrequenz (Versuche an Pflanzen und Tumoren.) *Zeitschr. f. Krebsforsch.*, 40: 117-121. 1933.
119. LUTZ, FRANK E. A much abused but still cheerful cricket. *Jour. N. Y. Entom. Soc.*, 35(1): 308. 1927.
120. MCCABRIGHT, J., and G. M. MCKINLEY. Biological effects of temperature variations with high-frequency oscillations. *Proc. Soc. Exp. Biol. and Med.*, 27: 841-843. 1930.
121. MCKINLEY, G. M. Some biological effects of high-frequency electrostatic fields. *Proceed. Penn. Acad. Sci.*, 4: 43-46. 1930.
122. —, and D. R. CHARLES. Certain biological effects of high-frequency fields. *Science*, 71 (1845): 490. 1930.
123. —, and T. G. MCKINLEY. The vacuum tube oscillator in biology. *QUART. REV. BIOL.*, 6: 322-328. 1931.
124. —. The ultra-high-frequency magnetic electric field in biology. *Univ. Pittsburgh Bull.*, 30: 2. Nov., 1933.
125. MCKINLEY, JOHN G. and G. MURRAY MCKINLEY. High-frequency equipment for biological experimentation. *Science*, 71(1846): 508-510. 1930.
126. McLENNAN, J. C. The heating effect of short radio waves. *Jour. Maryland Acad. Sci.*, 2. 14-24. 1931.
127. —, and A. C. BURTON. Selective heating by short radio waves and its application to electrotherapy. *Canad. Jour. Res.*, 5: 550-566. 1931.
128. —, and —. The heating of electrolytes in high-frequency fields. *Canad. Jour. Res.*, 3(3): 224-240. 1930.
129. MAGROU, J., M. MAGROU, and M. P. REMS. Actions à distance de divers facteurs sur le développement de l'oeuf d'Oursin. *Compt. Rend. Acad. Sci. (Paris)*, 189: 779-782. 1929.

130. MAGROU, J., and M. MAGROU. Radiations mitogénétiques et genèse des tumeurs. *Compt. Rend. Acad. Sci. (Paris)*, 184: 905-907. 1927.
131. MALOV, N. N. Einige Bemerkungen zur Frage des Körperwiderstandes bei Hochfrequenz. *Hochfrequenztechnik u. Elektroak.*, 41(4): 138-141. 1933.
132. —. Untersuchung der Ultraschallwellen mittels Widerstandsthermometers. *Hochfrequenztechnik u. Elektroak.*, 42(4): 115-119. 1933.
133. —. Messung zur Erwärmung von Flüssigkeiten im hochfrequenten Kondensatorfeld. *Hochfrequenztechnik u. Elektroak.*, 42(6): 190-194. 1933.
134. —. Zur Frage der selektiven Erwärmung der Gewebe bei Ultrakurzwellen. *Phys. Zeitschr.*, 34: 880-883. 1933.
135. —. Statisches Voltmeter für ultrahohe Frequenzen. *Phys. Zeitschr. d. Sowjetunion*, 7: 583-589. 1935.
136. —. Die Berechnung der Erwärmung von zylindrischen Körpern im Kondensatorfelde. *Zeitschr. f. Physik*, 90: 802-809. 1934.
137. —. Isuchenie teplovogo effecta v elektricheskome pole ultrakorotkikh i korotkikh voln i ikh "specificheskogo" deistviia. *Biologicheskii Zhurnal (Jour. Biol.)*, 5(3): 551-560. 1936.
138. —, and HENRICH FRUSEN. Morfosi u *Drosophila melanogaster* visvannii vosdeistviem elektricheskogo polia ultravisokoi chastoti. (Morphosis in *Drosophila melanogaster* induced by action of the electrostatic field of ultrahigh-frequency.) *Biologicheskii Zhurnal (Jour. Biol.)*, 5(3): 561-568. 1936.
139. MARKUSE, K. P., D. A. LOMINSKY, and N. MALOW. Einfluss ultrakurzer Wellen auf den Mäusekrebs. *Ztschr. f. Krebsforsch.*, 44: 415-421. 1936.
140. MARSHALL, W. H. Heating of simple solutions and emulsions exposed to high-frequency high potential electrostatic fields. *Jour. Gen. Physiol.*, 13: 637-646. 1930.
141. MASLENNIKOV, M. N. Samechatelnii opit Dnepropetrovzev rasprostranit po soiuzu. (Spread widely the experience of Dnepropetrovsk province.) *Elektrifikatsiia Sel'skogo Khoziaistva*, 2: 34-35. 1937.
142. MELLON, RALPH R., WACLAU T. SZYMANOWSKI, and ROBERT ALAN HICKS. An effect of short electric waves on diphtheria toxin independent of the heat factor. *Science*, 72(1859): 174-175. 1930.
143. METLITZKY, L. V., and V. P. SOBOLEVA. Isuchenie letalnogo deistviia elektricheskogo polia visokoi chastoti na kultury gribov *Sclerotinia libertiana* i *Botrytis cinerea*. (Predvaritelnoe soobshchenie). (The lethal action of high-frequency field on *Sclerotinia libertiana* and *Botrytis cinerea*. (Preliminary report.)) *Zashchita Rastenii (Plant Protection)*, 10: 32-36. 1936.
144. MEZZADROLI G., and E. VARETON. Prove di confronto fra l'azione esercitata dalle onde elettro magnetiche ultra corte ($\lambda = 2-3$ m.) e dal circuito oscillante Lakhovsky sulla germinazione de semi e sull'accrescimento della piante. *Rend. R. Accad. Lincei*, X, ser. 6 (5/6): 289-298. 1929.
145. —, and —. Azione esercitata dalle onde elettromagnetiche ultracorte sul potere catalasico dei semi. *Rend. R. Accad. Lincei*, XI: 429-433. 1930.
146. MOUROMTSEFF, I. E. Oscillator kills grain weevils in few seconds. *Electrical World*, 102: 667-668. 1933.
147. NAKAHARA, WARO, and RYUJI KOBAYASHI. Biological effect of short exposure to supersonic waves: local effect on skin. *Jap. Jour. Exper. Med.*, 12: 137-142. 1934.
148. NAKAMURA, H., M. YAMADA, K. TANAKA, M. WAKABAYASHI, and S. SASADA. An experimental study on the inhibitory influence of short and ultra-short waves on the development and growth of malignant tumors. *Gann.*, 30: 548-560. 1936.
149. NABBIT, E. S., F. W. BISHOP, and S. L. WARREN. Physiological effects of high-frequency current. *Amer. Jour. Physiol.*, 96: 439-448. 1931.
150. NIKITIN, B. L. (A brief note.) *Elektrifikatsiia Sel'skogo Khoziaistva*, 1: 44. 1935.
151. NIMEN, H. F. Das Zweifadenelektrometer als Wechselspannungsmesser für hohe Frequenzen. *Hochfrequenztechnik u. Elektroakustik*, 42(1): 24-26. 1933.
152. OKKILA, H., and K. OVERGAARD. Effect of high-frequency currents upon normal tissues and malignant tumours in mice. *Arch. Exper. Zellforsch.*, 19: 466-470. 1937.
153. OSWALD, KURT. Messung der Leitfähigkeit und Dielektrizitätskonstante biologischer Gewebe und Flüssigkeiten bei kurzen Wellen. *Hochfrequenztechnik u. Elektroakustik*, 49(2): 40-49. 1937.
154. PAIC, M., V. DEUTSCH, and I. BORCILA. Action des ultrasons sur des microbes, les protozoaires et les infusoires. *Compt. Rend. Soc. Biol. (Paris)*, 119: 1063-1065. 1935.
155. —, P. HABER, J. VONT and A. ELIAEZ. Action biologique des ultrasons. *Compt. Rend. Soc. Biol. (Paris)*, 119: 1061-1063. 1935.

156. PÄTZOLD, J. Die Erwärmung der Elektrolyte im hochfrequenten Kondensatorfeld und ihre Bedeutung für die Medizin. *Zeitschr. f. Hochfrequenztechnik.*, 36: 85-98. 1930.
157. —. Zur Physik der Ultrakurzwellentherapie. Das Wellenband der selektiven Erwärmung. *Zeitschr. f. techn. Physik.*, 13: 212-216. 1932.
158. —, and P. BETZ. Der Einfluss der Elektrodenanordnung in der Ultrakurzwellentherapie auf die Wärmeverteilung im Körper. *Zeitschr. f. die Gesamte Exper. Medizin.*, 94(4): 696-707. 1934.
159. PFEIFFER, H. Versuche zur Emission elektrischer Wellen durch lebende Protoplasten. *Protoplasma*, 28: 82-85. 1937.
160. PIRRONI, F. Ricerche nel campo dell'alta frequenza. Azione biochimica delle onde elettromagnetiche ultracorte. I. *Atti Accad. Naz. Lincei*, VI, s. 19: 108-111. 1934.
161. POSPELOV, A. P., I. V. ZHILENKOV, D. P. BURNATSKY, and I. D. BUROMSKY. Vliianie ultrakorotkikh elektromagnitnikh voln na processy prorostraniia semion. (Effect of ultra-short electromagnetic waves on the processes of germinating seeds.) *Zapiski Voronezhskogo Sel'skikhkhoziaistvennogo Instituta*, I (16): 295-303. 1935.
162. POTAPENKO, G. Investigations in the field of the ultra-short electro-magnetic waves. I. The generator for the production of ultra-short undamped waves. *Physical Review*, 39: 625-637. 1932.
163. —. Investigations in the field of the ultra-short electro-magnetic waves. II. The normal waves and the dwarf waves. *Physical Review*, 39: 638-665. 1932.
164. PYENSON, LOUIS. The shielding effects of various materials when insects are exposed to the lines of force in a high-frequency electrostatic field. *Jour. N. Y. Ent. Soc.*, 41: 241-252. 1933.
165. REITER, T. Tumorerstörung durch Ultrakurzwellen. *Deutsche med. Wochenschr.*, 59: 1497-1498. 1933.
166. RICHARDS, WILLIAM T., and ALFRED L. LOOMIS. The chemical effects of high-frequency sound waves. I. A preliminary survey. *Jour. Amer. Chem. Soc.*, 49: 3086-3100. 1927.
167. RIVERA, V. Guarigione di alcuni cancri vegetali con la cura dei raggi X. *Rend. R. Accad. Lincei*, 2: 142-144. 1925.
168. —. Soggi di radioterapia vegetali. *Bol. R. Staz. Patol. Veg.*, 6: 337-345. 1926.
169. —. Azione dei raggi X sopra i tumori vegetali. *Riv. di Biol.*, 7: 449-465. 1927.
170. —. Depressione ed esaltazione dell'accrescimento in neoplasmi vegetali sperimentale irradiati. *Riv. di Biol.*, 9: 62-69. 1927.
171. —. Azioni di forti dosi di raggi gamma sopra il "B. tumefaciens." *Rend. R. Accad. Naz. dei Lincei*, 7 (6a). 1928.
172. —. Azione di forti dosi di raggi γ sopra il "B. tumefaciens" Smith et Townsend. *Rend. R. Accad. Lincei*, 7: 867-869. 1928.
173. —. Influenza dei "circuiti aperti" di Lakhovsky sulla sviluppo di tumori nei vegetali. *Note e Mem. Lab. ed Observ. Patol. Veg. (Perugia)*, 5: 3-19. 1928.
174. —. Sulla radiosensibilità di *Vicia faba*. *Rivista di Biologia*, 10 (1): 155-185. 1928.
175. —. Influenza del trattamento di tubi di emanazione sopra lo sviluppo di alcuni microrganismi vegetali. *Bol. R. Staz. Patol. Veg.*, 9: 241-247. 1929.
176. —. Trattamenti di tumori da "Bacterium tumefaciens" sopra "Ricinus" con tubi di emanazione. *Mem. Lab. ed Observ. Patol. Veg. (Perugia)*, 6: 3-19. 1929.
177. —. Valore ed influenza della radiazione penetrante sull'accrescimento di vegetali terrestri all'inizio sviluppo. *Rivista di Biologia*, 12: 238-265. 1930.
178. —. Radiazione, ambiente ed accrescimento nei vegetali. *Rivista di Biologia*, 13: 324-361. 1931.
179. —. Secondo contributo alla conoscenza della influenza dell'energia raggiante ambientale sull'accrescimento di piante terrestri e di neoplasmi vegetali. *Rivista di Biologia*, 13: 236-323. 1931.
180. ROFFO, A. E., JR. La producción de las ondas cortas; su medición y su aplicación. *Bol. Inst. de Med. Exper. para el Estud. y Trat. del Cancer*, 11: 919-930. 1934.
181. RUBINSTEIN, D. L. Zadachi elektrobiologii v sel'skom khoziaistve. (Role of electrobiology in agriculture.) *Elektrofizika i Sel'skogo Khoziaistva*, 5-6: 140-142. 1935.
182. SACKI, H. Studies on the effects of X-rays radiation upon germination, growth and yield of rice plants. *Jour. Soc. Trop. Agr. Formosa*, 8: 28-38. 1936. (English summary.)
183. SAIDMAN, JEAN, ROGER CAHEN and JACQUES FORESTIER. Actions des champs électriques de très haute fréquence sur les tissus organiques. *Compt. Rend. Acad. Sci.*, 192: 452-454. 1931.
184. SALLOTTI, A., and O. FIORENZI. Risultati di ricerche sulla influenza di microonde di $\lambda = 60-70$ cm. sui vegetali. *Verb. I. Internat. Congr. Electro-Radio-Biol.*, 1: 440-444. 1935.

185. SCHAEFER, H. Hochfrequenzfähigkeit des Blutes bei Ultrakurzwellen von 3-6 m. Wellenlänge. *Klin. Wochenschr.*, 12: 102-103. 1933.
186. SCHAEFER, HARRY. Ultrasonics and supersonics. *Electronics*, January 1938; p. 34.
187. SCHERESCHESKY, J. W. The physiological effects of currents of very high frequency (135,000,000 to 8,300,000 cycles per second). *Public Health Rpts.*, 41: 1939-1963. 1926.
188. —. Heating effects of very high-frequency condenser fields on organic fluids and tissues. *Public Health Rpts.*, 48: 844-858. 1933.
189. —. Biological effects of very high-frequency electromagnetic radiation. *Radiology*, 20: 246-253. 1933.
190. —, and H. B. ANDERVONT. The action of currents of very high frequency upon tissue cells. A. Upon a transplantable mouse sarcoma. B. Upon a transplantable fowl sarcoma. *Public Health Rpts.* 43: 927-945. 1928.
191. SCHLIEPHAKE, E. Die biologische Wärmewirkung im elektrischen Hochfrequenzfeld. *Deutsch. Gesellschaft für innere Med.*, 40: 307-10. 1928.
192. —. Die Reaktionsweise des Organismus auf kurze elektrische Wellen. Hyperthermie als elektro-biologische Wirkung. *Klin. Wochenschr.*, 7: 1600-1602. 1928.
193. —. Tiefenwirkungen im Organismus durch kurze elektrische Wellen. *Zeitschr. f. Gesam. Exp. Med.*, 66: 212-264. 1929.
194. —. Therapeutische Versuche im elektrischen Kurzwellenfeld. *Klin. Wochenschr.*, 9 (50): 2333-2336. 1930.
195. —. Ueber Tiefenwirkung und elektive Gewebewirkung kurzer elektrischer Wellen. *Strahlentherapie*, 38: 655-664. 1930.
196. —. Ultrakurzwellen in der Medizin. *Die Umschau*, 36 (43): 845-849. 1932.
197. —. Schallachwingungen in der Therapie. *Klin. Wochenschr.*, 14: 1689-1690. 1935.
198. SCHMIDT, F. O. Ultrasonic micromanipulations. *Protoplasma*, 7: 332-340. 1929.
199. —, A. R. OLSON, and C. H. JOHNSON. Effects of high-frequency sound waves on protoplasm. *Proc. Soc. Exp. Biol. and Med.*, 25: 718-720. 1928.
200. —, and BERTHA UHLMAYER. The mechanism of the lethal effects of ultra-sonic radiation. *Proc. Soc. Exp. Biol. and Med.*, 27: 616-628. 1930.
201. SCHWETZER, G. Die Kurzwellentherapie in der inneren medizin. *Med. Klin.*, 31: 1578-1580; 1614-1616. 1935.
202. SHAROSCO, E. A. (Abstract.) *Elektrofizicheskaia Selskogo Khozjajstva*, 1: 41. 1933.
203. —. Nekotore voprosi deistviia UKV na semena pshenitsi. (Action of ultra-short waves on wheat seed.) *Elektrofizicheskaia Selskogo Khozjajstva*, 5-6: 150-153. 1935.
204. SHERRARD, C., and C. B. PRATT. Changes in temperatures of tissues after systematic applications of short wave electric fields. *Proc. Soc. Exp. Biol. and Med.*, 32: 763-766. 1935.
205. SIMIUK, U. N. Vliianie UKV na povishenie vakhozhesti i uskorenie proroastaniia tugovsk-hozhikh semion. (Action of ultra-short waves on increase and speeding up of germination in seeds difficult to germinate.) *Elektrofizicheskaia Selskogo Khozjajstva*, 1: 38-40. 1935.
206. SOKOLNIKOV, O., E. BUKHARINA, V. GLEBOVA, and E. UGRENINOVA. Puti isucheniiia biokhimicheskikh sdvigo pri primenenii KV v medicine. (Means of studying biochemical changes in application of short radio waves in medicine.) *Arkhiv Biol. Nauk (Arch. des Sciences Biologiques-Moscow)*, 43 (1): 89-99. 1936.
207. SPRAGUE, GEORGE F. Some genetic effects of electromagnetic treatments in maize. *Anat. Rec.*, 47: 382. 1930.
208. STANLEY, W. M. The action of high-frequency sound waves on tobacco mosaic virus. *Science*, 80: 339-341. 1934.
209. STAPP, C. Der bakterielle Pflanzenkrebs und ungeeignete Verfahren zu seiner Bekämpfung. *Die Umschau*, 37: 978-980. 1933.
210. —, and H. Bortels. Der Pflanzenkrebs und sein Erreger, *Pseudomonas tumefaciens*. *Zentrbl. Baktr. etc.*, 2 Abt. 88: 313-319. 1933.
211. STEIN, EMMY. Ueber den durch Radiumbestrahlung von Embryonen erzeugten erblicher Krankheitskomplex der Phytocarcinome von Antirrhinum majus. *Phytopath. Zeitschr.*, 4: 523-538. 1932.
212. STIRBOCK, L. H. Biologische Wirkung ultrakurzer Wellen. *Wim. klin. Wochenschr.*, 44: 291-293. 1931.
213. STOYE, KARL. Tier und Pflanze im Kurzwellenfeld. *Die Umschau*, 37 (29): 565-566. 1933.
214. STRAUDEL, HAROLD. Kristallsteuerung für ultrakurze Wellen. *Hochfrequenztechnik u. Elektroakustik*, 46 (1): 4-6. 1935.
215. SZYMONOWSKI, W. T., and ROBERT A. HICKS. The biologic action of ultra-high-frequency currents. *Jour. Inf. Dis.*, 50: 1-25. 1932.
216. TAKAHASHI, WILLIAM N., and RALPH J. CHRISTENSEN. The virucidal action of high-frequency sound radiation. *Science*, 79 (2053): 415-416. 1934.

217. TARATIN, P. P. Wheat storage and ultra-short waves. (Note) *Electronics*, April p. 53. 1937.
218. TARUSOV, B. N. Biologicheskoe deistvie ultrakorotkikh voln. (Biological action of ultra-short waves.) *Uspokhi Sovremennoi Biologii*, 3 (3): 356-361. 1934.
219. —. O deistvii na semena elektricheskikh polei ultravisokoi chastoti. *Elektrifikatsiia Selskogo Khoziaistva*, 2: 36-37. 1937.
220. TAYLOR, H. J. The effect of the high-frequency field on experimental rat tumours with special reference to the so-called "specific effect". *Brit. Jour. Radiol.*, 8: 718-721. 1935.
221. TIMKOVSKY, V. P. O metodike visokochastotnikh ismerenii. (On methods of measurement of ultra-high-frequencies.) *Elektrifikatsiia Selskogo Khoziaistva*, 1: 40-41. 1935.
222. TURENIAKOVA, M. M., and M. A. VASILYEVSKII. Opity po oblucheniiu semion i klubnei rastenii luchami Rentgena. (Experiments on irradiation of seeds and tubers with Röntgen rays.) *Izvestiia Akademii Nauk URSS; Otdel Matb. i Estestv. Nauk Ser. Biol.*, (1): 157-169. 1936.
223. TVERSKOI, D. L. Vliianie korotkikh i ultrakorotkikh radiovoln na griby i bakterii, patogennie dlia rastenii. (The effect of short and ultra-short radio waves on fungi and bacteria pathogenic to plants.) *Zashchita Rastenii* (Plant Protection), 13: 3-28. 1937.
224. —. (Abstract.) *Elektrifikatsiia Selskogo Khoziaistva*, 1: 45-46. 1935.
225. VANCE, CHARLES B. Velocity of sound in tubes at audible and ultra-sonic frequencies. *Physical Review*, 39: 737-744. 1932.
226. VISHNIAKOVA, M. S. Issledovanie letalnogo deistviia ultrakorotkikh voln na dolgoosikov i vliianie ikh na khoziaistvennuu godnost pshenitsi. (Analysis of the lethal action of ultra-short waves on weevils and its effect on agricultural fitness of wheat.) *Elektrifikatsiia Selskogo Khoziaistva*, 5: 26-33. 1934.
227. WHITNEY, W. R. Bursitis—X-rays—high-frequency. *General Electric Review*, 38 (2): 70-76. 1935.
228. WILLIAMS, O. B., and N. GAINES. The bactericidal effects of high-frequency sound waves. *Jour. Inf. Dis.*, 47: 485-489. 1930.
229. WOOD, R. W., and A. L. LOOMIS. The physical and biological effects of high-frequency sound waves of great intensity. *Phil. Mag.*, 4: 417-436. 1927.
230. WU, HSIEN and SZU-CHIH LIU. Coagulation of egg albumin by supersonic waves. *Proc. Soc. Exp. Biol. and Med.*, 28: 782-784. 1931.
231. YAOI, HIDETAKE, and WARO NAKAHARA. Effect of short exposure to supersonic waves on vaccine virus and some bacteria. *Jap. Jour. Exp. Med.*, 12 (2): 131-135. 1934.
232. YEN, ALBERT C., and SZU-CHIH LIU. Effect of supersonic waves on bacteria. *Proc. Soc. Exper. Biol. and Med.*, 31: 1250-1252. 1934.
233. —, and —. Effect of supersonic waves on bacteria. *Proc. Soc. Exper. Biol. and Med.*, 32: 485-488. 1934.





SEX DIFFERENCES IN MORBIDITY AND MORTALITY (*Concluded*)

By ANTONIO CIOCCO

Department of Biology, School of Hygiene and Public Health, The Johns Hopkins University

Age and the differences in mortality between the sexes

ONE of the main differences between the males and females, particularly in relation to the circulatory system, has been the higher mortality of the males from these causes that are characteristically associated with advancing age. The mortality rates for the five gross divisions of the age range used in Table 7, bear this out and also bring out a number of additional facts about the behavior of the two sexes with regard to mortality.

Considering the deaths from all categories and for all the age groups, it is seen that the absolute differences between the rates of the males and of the females is greatest for the deaths under 1 year of age, reaches a minimum for the 5 to 14 age group and increases thereafter. There are thus two age periods: infancy and late adulthood and old age in which the males exhibit a markedly higher mortality than the females. The higher male mortality during infancy in part is due to what might be regarded as the extension into post-natal life of the factors responsible for the high masculinity of stillbirths. Thus one notes the great difference between male and female infants relative to the mortality from prematurity and from injury at birth; both conditions discussed already in the previous section. Among the other causes that cannot be allocated

to any particular organ system those classed as violent and accidental deaths deserve some attention. At all ages, the mortality of the males from these causes is higher than that of the females. For the ages above 5 this might be explained by the differences in the environment of the two sexes, occupation for example, or merely the different exposure to risk due to the greater activity of the boy and man. Except that probably the male is more active than the female, it is difficult to imagine a greater exposure to risk of death for the male infant and yet the data show that for the ages under 5 the mortality rates from causes listed under these categories is higher in the males. For example, it is higher in the case of deaths from mechanical suffocation, drowning and falls and yet for all of these it would seem that the element of chance is alone involved. If it could be definitely shown that in the two youngest age groups as many or more females than males are subject to such accidents, the argument of those who believe in the inherent inferiority of the male would be greatly strengthened. At present a categorical position in the affirmative or negative cannot be taken although unpublished data, use of which has been kindly permitted by Dr. S. D. Collins of the United States Public Health Service, would seem to indicate that in infancy the incidence rate of accidents is actually higher in the

males than females. In a periodical canvass of 9,000 families made under Dr. Collins' direction from 1928-1931 (cf. Collins, 1940), twenty-eight accidents of all types were recorded for male infants and sixteen for female. The rates per 1,000 person-years experience as computed by Collins

When the sex differences in mortality due to the break-down of the several organ systems are considered in relation to age, the pattern of these differences becomes more definite if none the less complex. For deaths due to a break-down of the circulatory system, the higher male

TABLE 7

Mortality rates of males and females according to organ system involved. White population of the United States Registration Area, 1930

ORGAN-SYSTEM	MORTALITY RATES									
	Per 100,000 births		Per 100,000 population							
	Age classes (in years)									
	Under 1		1 to 4		5 to 14		15 to 49		50 and over	
	Males	Females	Males	Females	Males	Females	Males	Females	Males	Females
Circulatory, blood.....	439.8	317.8	32.0	28.3	20.5	20.6	66.7	52.5	1238.4	1037.8
Respiratory.....	1273.2	1075.4	199.0	183.5	33.7	33.3	118.0	92.2	423.0	344.7
Primary and secondary sex organs.....	56.2	42.3	1.4	1.2	.3	.8	6.5	75.4	124.0	197.1
Kidney and related excretory organs.....	23.4	23.6	7.1	7.1	4.1	4.9	25.7	33.4	466.2	395.3
Skeletal and muscular system.....	21.6	17.5	5.2	4.8	5.9	5.0	4.9	3.9	18.0	20.5
Alimentary tract and associated organs.....	1010.9	784.0	145.3	115.7	29.7	26.1	67.7	56.8	483.6	422.7
Nervous system and sense organs.....	245.2	237.6	49.3	42.8	23.7	17.0	66.8	36.7	578.3	499.9
Skin.....	56.0	51.7	2.2	2.9	.9	.8	2.8	2.3	27.9	19.8
Endocrinal system.....	78.5	54.1	4.2	3.7	2.2	2.7	5.9	10.7	72.8	136.1
<i>Non-specific causes of death</i>										
Violent and accidental deaths.....	101.4	84.2	66.8	51.2	49.2	20.8	117.5	23.2	218.5	136.1
Premature births.....	1777.8	1458.2	—	—	—	—	—	—	—	—
Injury at birth.....	595.9	399.5	—	—	—	—	—	—	—	—
Others.....	921.3	659.7	14.2	13.3	3.4	2.8	8.2	7.1	99.5	99.2
All deaths.....	6601.2	5205.6	526.7	454.5	173.5	134.8	490.7	394.2	3750.2	3309.2

are, 41.6 for males and 32.7 for females. The male's superiority in incidence rate is then of the same order as that noted with respect to mortality. In this communication, however, Collins remarks that the difference between the male and female rates equals 8.9 ± 8.2 and is therefore statistically insignificant. Increased information is obviously needed.

mortality is noticeable at the two extremes of the age range. In infancy the higher male mortality is due almost entirely to congenital malformations of the heart, already mentioned. As has also been already stated there is a higher male mortality from diseases of the chronic degenerative type and the effects of this are to be noted for the 50 years and over group.

A notable exception to the higher masculine mortality from cardiovascular diseases is constituted by diseases of the endocardium for which neither sex prevails consistently and from 5 to 49 years of age the females have the higher mortality. For the under 1 age group the male death rate (per 100,000) is 13.7 compared to 10.8 for the females, in the next age group it is respectively 3.3 and 3.0, for the 5 to 14 years age groups instead one finds 7.6 males and 8.9 females, and for the 15 to 49 years age period the rates are respectively 19.7 and 20.5. After 50 years of age there is again a return to a higher male mortality, the rate being 243.2 as compared to 231.2 in the females.

Altogether, the sex differences among deaths from causes demonstrating a break-down of the respiratory system follow the same age pattern as those from diseases of the circulatory system. The highest differences occur at the two extreme age groups. There are, however, some notable exceptions to the general higher death rate of the males from this group of causes. In the first place, at all ages more females than males die of whooping cough. Secondly, at the oldest ages more women than men die from bronchitis (all forms) and from influenza (all forms). For the former condition the mortality of the males equals 84.8 compared to 90.9 for the females, for the latter the rates are, respectively, 47.1 and 50.9. Thus, the data suggest that the higher male mortality from respiratory conditions is a consequence mainly of a greater liability to a break-down of the lungs proper. For the time being, the comparative female mortality from whooping cough and, in the older ages, from bronchial diseases cannot be attributed to a weakness of any specific organ or structure although it is to be noted that in the complex pathological picture of whooping cough

deaths are found those lesions of the bronchi and lungs to which MacCallum has given the name of interstitial bronchial pneumonia.

As it is apparent in Table 7, the differences in the mortality between the males and females from conditions involving the nervous system do not become striking until the adult years are reached. This is to be expected since among the death causes that exhibit a high masculinity are alcoholism, suicide, tabes dorsalis, and general paresis. In infancy and childhood the prevalence of meningitis among the males is offset by the higher female mortality rates from congenital hydrocephalus and spina bifida meningoceli. It will be recalled that both of these conditions, when they cause stillbirths, are also found more often in females. Incidentally, the most important cause of death in the oldest age group, cerebral hemorrhage, affects the females slightly more than the males in that period. In the younger age classes it is relatively prevalent at times in the males and at others in females.

A study of the age specific rates for the diseases listed under alimentary tract does not alter sensibly the picture presented above. The higher rate for the male infants relative to diseases of the alimentary tract results from the high masculinity of deaths due to diarrhea and enteritis. The preponderance of the males then, seems to be associated particularly with a break-down of what might be considered the gastro-intestinal tube while, in general, the females seem to show greater liability to a functional failure of the specialized glands which represent a later development of the embryonic gut. The apparent exception is cirrhosis of the liver, but the greater masculine mortality from this condition may actually be the result of environmental factors.

In passing, it will be observed that other diseases of the pancreas besides diabetes and other diseases of the gall bladder besides biliary calculi show a higher female mortality. This has important significance inasmuch as it suggests that the tendency of the gall bladder and pancreas to break-down more often in the case of the female does not depend upon a particular etiological factor.

As the data of both Tables 5 and 7 indicate, the higher mortality of the males due to the break-down of kidneys and related excretory organs is concentrated entirely in the age class of 50 years and above. In the three youngest groups there is very little difference between the rate of the males and females, and for the 15 to 49 years age class the women definitely have higher rates, as expected from the incidence of puerperal albuminuria and eclampsia.

For the causes of death listed in the skeletal and muscular system there is a consistent though not marked higher masculinity until the age class 50 and over is reached. In this group there is a prevalence of women. The preponderance of males noted in the first four age groups is associated principally with rickets, osteomyelitis, tuberculosis of the bones, joints and vertebrae. The females instead show a higher relative frequency in relation to acute rheumatic fever and chronic rheumatism. Although the number of cases on which these rates are based is not large, corroborative evidence will be presented later to show that these findings probably present a true picture of the sex differences in the mortality from these conditions.

The age trend of the comparative mortality rates from causes included in the group of endocrine diseases and in that of the primary and secondary sex organs exhibits a noteworthy parallelism. Rela-

tive to both groups the males have a higher rate in the first year of life. This is associated with diseases of the thymus and with congenital syphilis. The higher male mortality during infancy from congenital syphilis is in accordance with the findings on stillbirths and the question is again raised whether the sex selectivity is dependent upon the inferior resistance of the male or to a previous elimination of the females in the early stages of embryonic life. The higher female rates found after adolescence for deaths due to the break-down of the endocrinal system and that of the primary and secondary sex organs are associated with diabetes, diseases of the thyroid and with diseases related to pregnancy. The latter furnish the bulk of the female mortality from diseases included in the class of primary and secondary sex organs, but it is of importance to note that during adulthood cancer and other tumors of the breast contribute heavily to the female mortality. From this sketchy statistical description of the sex differences in the post-natal mortality for the year 1930 among the white persons in this country, a number of important deductions can be drawn. It appears, first of all, that during childhood and adolescence the sex differences in mortality—the higher mortality of the males—is barely perceptible. The trend of the differences, if considered by itself, would suggest that two series of factors are responsible for the higher male mortality. One factor would be the inherent biological inferiority of the males that brings about the elimination of the weaker in the early period of life. The other would be the environmental conditions related to the particular functions of the male in the social group. Secondly, considering the mortality due to the break-down of the several principal organ-systems, it is seen that not for all groups of

diseases do the males exhibit a higher mortality, and in those instances where they do have a higher death rate, it is in general due to only some of the diseases included in the category. Furthermore, when the causes of death for which the males definitely predominate are examined, one notes: pneumonia, cancer of the skin, alcoholism, suicide, diarrhea and enteritis, tabes dorsalis, general paresis, stomach and duodenal ulcers, all conditions in which the environment and the social function of the male may play a very important part. On the other hand, the males have a markedly higher mortality from diseases involving the arteries and the myocardial layer of the heart and from malignancies of the buccal cavity, digestive tract, and bladder. So far as any precise knowledge of the etiology of these conditions is available, it would seem that they are probably dependent more upon the inherent biological constitution than on other factors. There are certain causes of death for which there is not a male but a female preponderance. It is particularly noticeable that the females die more than the males from the diseases of the gall bladder and of the thyroid. The more frequent break-down of the endocrinal system in the females is not only found relative to the thyroid but also in relation to the pancreas; the diabetic mortality being much higher in this sex.

From the detailed consideration of the causes responsible for the deaths, it is seen that the so-called inferiority of the male is not general but specific, that is, it is limited to certain conditions. In turn, the females also manifest a greater liability to particular causes of death. In addition, however, it becomes clear that for those diseases or groups for which either of the two sexes demonstrate a higher mortality the causal element may not be always connected with maleness or

femaleness. The higher male mortality during infancy might be considered as an indication of an inferior biological structure. However, even in this case, caution must be used in assuming that exposure to risk of dying is equal in the two sexes. Bearing on this point are the data reported with reference to accident incidence. *A priori*, it would seem that among infants the liability to accidents should be equal in the two sexes, but apparently it may not be so. Therefore, it is of great importance to ascertain, so far as the available information permits, whether the differences in mortality noted above result from a difference in liability to a particular cause of death or in resistance to it.

Morbidity in the two sexes

With but few exceptions adequate data regarding the attack or case rate of illnesses do not exist. For the majority of diseases the only information available is that given in the summaries of clinical and hospital reports, which in general express the sex differences in terms of ratios of males to females, or else just mention whether there is a preponderance of one or the other sex in the sample collected. Such statistics are faulty for a number of obvious reasons. The method of selection of the sample, the age distribution, the race (color) and other characteristics of the individuals are omitted more often than not. Furthermore the size of the sample is rarely large enough since usually it represents the experience of one man or one clinic. In order to obviate some of the inadequacies of the available information an attempt has been made to bring together here the conclusions reached by a number of observers and authorities. But while the medical literature on the subject has been investigated as thoroughly as possible, for the purpose of this paper only those reports have been utilized

that deal with the disease conditions noted above and for which the mortality rate of one sex is significantly higher than that of the other. So far as was feasible only data based on the white population of this country have been used.

In the same order as above the diseases are presented, grouped in the 9 categories of Pearl's classification.

I. *Circulatory system, blood and blood-forming organs.* Arteriosclerosis is found more often in males according to all students of the subject (cf. Boyd, 1938). Evidence to support such an assertion is plentiful. In the morbidity survey made by De Porte (1933) in rural New York State it was found that of 1934 individuals 9.9 percent of the males and 7.7 percent of the females had arteriosclerosis. Wykoff and Lingg (1926) report that the males constituted 75 percent of the 234 persons with arteriosclerosis they encountered in the survey they conducted for the New York Heart Association. The experience of the Mayo Clinic, according to Allen (1934), demonstrates that over 5 times more males than females are affected by this condition. In addition to arteriosclerosis, thrombo-angiitis obliterans, a disease of the arterioles, also occurs with greater frequency among the males according to Allen's report, the ratio being 90 males to 1 female. As a matter of fact it is probably higher since as Boyd says it is a condition practically confined to the male sex alone. Allen and also Goodridge (1929) cite Buerger as having seen only 3 women in 500 cases.

Among the other diseases in this class one notes as for the mortality, a prevalence of males among the persons affected by diseases of the myocardium, the coronary vessels, the aorta and pericardium; and the several clinical surveys and observations are all in agreement.

For example, Sprague (1937) concludes that coronary sclerosis occurs three times as often in males as in females. Such is the opinion of White (1937) relative to coronary insufficiency, although for this condition the ratios reported reach 30 to 1. Myocardial degeneration has been seen twice as frequently in males as in females according to Eggleston (1929). Allen (1934) reports a ratio of 7 to 1 for myocardial infarction. Angina pectoris is well known to occur from four to six times more often in males [cf. Allen (1934), Brooks (1929), Boyd (1938), Smith (1934), etc.]; so also does aneurysm of the aorta, syphilitic heart disease and aortitis, according to Cowan and Ritchie (1935), Osler (1935), Smith (1934), Brown (1929), Christian (1935), and De Porte (1933). Pericarditis is also found to be more frequent in males [cf. Osler (1935), Morris (1929), Smith (1934)], the ratio being about two to one according to Allen's experience.

The age variations in the sex incidence of morbidity from endocarditis apparently parallel in certain respects that observed in mortality. Chronic mitral endocarditis is apparently more frequently in females according to Allen, the ratio being about two to one. White believes that in general women are more prone to valvular heart disease because they are more liable to rheumatic infection which is by far the most important etiologic factor associated with this form of heart disease, particularly in childhood and youth. However, with advancing age arteriosclerosis and syphilis accompany this disease more often and since they are preponderant in men, the sex ratio is altered. It is the etiologic factor then and not a specific sex weakness of the structure that brings about the alternative greater female and male mortality from valvular heart disease. In effect, the conditions which

constitute what is diagnosed as rheumatic heart disease prevail in females by two to one in Coombs's (1924) series of cases, although in De Porte's and Wykoff and Lingg's data the ratio was somewhat lower. Wilson *et al.* (1928), however, from their observations on children obtained the same results as did Coombs.

Summing up, it is found that there is correspondence between the sex incidence in morbidity and in mortality from the more important diseases associated with a break-down of the heart and circulatory system.

II. *Respiratory system.* In this group lobar pneumonia and pleurisy are the causes of death that manifest a significantly high masculinity and it would seem that these diseases actually occur more often in the males. In Osler's textbook it is stated that in 12,098 collected cases of lobar pneumonia, 73 percent were males and 27 percent females. Hoffman's (1913) summary of the Johns Hopkins Hospital experience from 1892 to 1911 shows that 341 male white patients and only 102 white females were admitted for diseases of the lungs (tuberculosis not included) during that period. During 15 years of observation at that hospital, according to Osler, 194 patients with sero-fibrinous pleurisy were seen and of these 161 were males and 33 females. On the whole this illustrates the general observations reported by Barach (1933), Trask (1937), Cecil (1937), Austrian (1939), Stallybrass (1931) and others. De Porte's 1927 morbidity survey in rural New York State showed that acute lobar pneumonia was reported in 78 males and 53 females.

What data there are on the sex frequency of influenza in non-epidemic conditions are not useful for the purposes of this study due to a variety of reasons. In the 1918 epidemic, Frost's (1919) study indicates that on the whole the attack

rates were higher for the females than for the males. Vaughan's (1921) observations of the 1920 epidemic in Boston bring out a similar relation. In addition, Vaughan says that, on the average, the women had also a higher proportion of severe cases. A very interesting observation is reported by Frost regarding the case fatality from influenza during the 1918 epidemic. He noted that between the ages of 15 and 60 the men, not the women, had a higher fatality rate. This is accounted for by a higher incidence of pneumonia in the males together with a higher mortality from this disease. Vaughan, in the epidemic he studied, found the same—5.2 percent of the males developed pneumonia and recovered and 1.9 per cent died, while 3.6 per cent of the females developed non-fatal and .4 per cent developed fatal pneumonia. Although it may be that epidemic influenza has characteristics of its own, these findings would suggest that the higher masculine mortality from this disease at several age periods may be due entirely to the greater susceptibility of the male to pneumonia.

Whooping cough is one of the major causes of death showing at all ages a female instead of a male preponderance. Data on the attack rate of the disease in general appear to reveal the same. Godfrey's (1928) observations in New York State inclusive of New York City, Laing and Hay's report from Aberdeen (1901), the report of the British Medical Research Council (1938), all note that the females are attacked relatively more often than the males. Sydenstricker's (1928) data from Hagerstown, Maryland, and De Porte's findings in rural New York are the only two studies where a slight excess of males has been found among the cases having the disease. Since the frequency of deaths from this disease is somewhat

unusual relative to the sex incidence many have speculated upon its significance. Holmes (1926), Young and Russell (1927, and Hill (1933) have all discussed the matter at length. They have come to the conclusion that the sex differences are not associated with differences in size of larynx or with peculiar sensitivity of the nervous system but rather to a difference in susceptibility to the specific organism.

IV. *Kidneys and related excretory organs.*

As the data on mortality have shown, on the whole for this group of conditions there is not a striking difference between males and females. In Osler's textbook it is stated that the males are rather more subject to chronic nephritis than are the women. Hoffman's study of the admissions at the Johns Hopkins reveals that 575 males and 521 females were found to have diseases of the kidneys. However, Allen's report from the Mayo Clinic would indicate that twice as many males as females are affected with glomerular nephritis. On the other hand, De Porte reports that more females than males were found to have chronic interstitial nephritis (Bright's disease) in the morbidity survey in rural New York, the figures being 652 women and 482 men. A similar relation was observed for acute nephritis: 285 females and only 165 males being reported. In a way, these last findings would seem to contrast with McCann's (1934) statement that acute hemorrhagic nephritis is found with about equal frequency in both sexes during childhood but that later in life the males have a higher incidence. Altogether these observations suggest, then, that there is no clear-cut predominance of one or the other sex with respect to diseases causing directly the break-down of the kidneys.

V. *Skeletal and muscular system.* On the whole, the sex incidence of the diseases of this group corresponds to that observed

relative to mortality. Osteomyelitis, as Allen shows, is found twice more often among males than among females. With regard to rickets, there is some uncertainty about a sex difference in susceptibility. Hess (1929) is unable to arrive at any definitive conclusion although he and others have observed late rachitic sequelae more often in boys than in girls.

Taking together all manifestations of rheumatic fever, the consensus of opinion is that it occurs more often in females than males during the age period of its highest incidence, childhood and adolescence. Osler (1935), Swift (1937), Torrey (1935), and Sydenstricker (1934) concur in this conclusion. Thomson and Findlay's (1933) report on 701 children seen in Glasgow supports this view. Of these, 63 per cent were girls and 37 per cent were boys. While at later ages there appears to be no sex difference in the attack rate, or maybe a slight masculine predominance, the higher fatality noted for the females can be accounted for by the association of the childhood disease to endocarditis.

Chronic arthritis also occurs more often in females, if gout is excepted. Glover (1928), who has summarized his own and other data on the subject, notes that for this disease the females are twice as susceptible as the males. This is in fair agreement with the observations of Torrey (1934), those of Cecil (1937), Allen (1934) and others. In De Porte's survey, 1092 males as compared to 1148 females were affected by this condition. It should be noted here that Dawson believes that the female prevalence is to be observed particularly during the period of sexual maturation and at the menopause.

VI. *Alimentary tract and associated organs concerned in metabolism.* The higher mortality of the males from diseases of the intestinal tract is apparently associated

with a higher male morbidity from such conditions. Boyd (1938), Griffith and Graeme Mitchell (1937), Hempelmann (1935), and others have noted that malformations and abnormalities of this organ system are found more often in males. For example in 358 cases of Meckel's diverticulum that Boyd collected, only 72 were in girls.

Duodenal ulcers occur much more frequently in males than females. Eusterman and Balfour (1936) for instance have operated on 551 males and only 150 females. Hosoi and Alvarez (1930) found a ratio of over three males to one female in the series collected at the Mayo Clinic. An interesting observation by these authors is that gastrojejunal ulcer has been found over seven times more often in males but simple gastric ulcer is observed somewhat more frequently in females. In Osler's textbook a statement to the same effect is made and Brown (1929) cites the results of Moynihan's clinic where in 164 operations for simple gastric ulcers, 83 were on men and 81 on women. These findings indicate then that males tend statistically to show an organ weakness relative to the intestinal tract, but not to so marked a degree for the stomach. This is in agreement with the mortality data reported above where the sex differences were significant only with respect to the intestinal tract, while for the deaths from diseases of the stomach the proportion of the sexes was not strikingly different. Further confirmation on this point is obtained from the report of Hosoi and Alvarez. These authors have observed more males than females among cases of cancer of the intestines, but about an equal number of men and women among cases of cancer of the stomach. Cirrhosis of the liver and malignancy of this organ are somewhat more frequent in males than females.

But Hosoi and Alvarez's data indicate that this masculine preponderance is not very marked, since in their series the ratio was about 1.3 to 1. Other writers, as for example Stengel and Kerr (1922) and Rolleston and McNee (1929), raise this ratio to between 2 and 3 to 1.

While acute appendicitis, according to Lewis (1929), is more common in men, since he found 959 males (60 per cent) in a series of 1577 cases, Hosoi and Alvarez find only a slightly higher number of males in the series of cases they record. De Porte reports 453 men and 513 women among the cases of appendicitis noted in the morbidity survey of 1927 in rural New York. It would seem then that the sex differences in the mortality from this condition are not associated always with a corresponding difference in morbidity. It must be remembered, however, that the fatality rate from this condition depends on a number of extraneous circumstances not connected with the individual physical resistance. The same can be said about typhoid fever for which the mortality was found higher in the males. The attack rate for this disease depends entirely on the cause of the outbreak. Whether or not males are more apt to die, everything being equal, is a matter regarding which there is little conclusive evidence.

Pellagra is one of the conditions in this class for which the mortality is higher in the females. Goldberger *et al.* (1929), Vanderhoff (1929), Zimmerman (1937), Musser (1934) all agree that women are slightly more susceptible. Official statistics (1926) regarding admissions to institutions for mentally deranged reveal that in 1922 the first admission rate from pellagra psychosis was for white urban males equal to 0.1 per 100,000 population, for the females it was 0.3. For males coming from rural areas the rate was 0.3 while for females it was 0.8.

A break-down of the gall bladder also causes death in more females than males. Boyd (1938) says that females are always more subject to it. Hosoi and Alvarez noted cholelithiasis almost three times as frequent, and cancer of the gall bladder almost four times more often in women than men. For the latter disease, Rolleston and McNee (1929) have summarized the findings reported in the literature, both American and foreign, and state that the rate of females to males varies from 3 to 1, to 5 to 1. These same authors report that in general gall-stones are said to occur from two to three times more often in women than in men, a statement with which there appears to be general agreement.

VII. *Nervous system and sense organs.* There is no doubt that tabes dorsalis not only causes more deaths among males than females but is also found more often among men. Osler and also Stallybrass have stated that 10 males to 1 female are affected by this condition. As a matter of fact all forms of neurosyphilis occur more often in men according to the above authors and others. The question, however, is whether or not this male preponderance is not dependent upon the higher rate of syphilis among men, a fact well established [cf. Le Blanc (1925)]. Turner's (1930) data based on 10,000 consecutive hospital admissions would indicate that the higher incidence of syphilis among men is not in itself responsible for the frequency with which central nervous system involvement occurs in this sex but that actually the males seem to be more prone to neurosyphilis. He found that 39 per cent of the male syphilitics had some form of neurosyphilis as compared to only 22 per cent of the females.

Among the diseases included in this group the various forms of meningitis all

show a masculine preponderance in attack as well as mortality rate. Levinson (1937) is of the opinion that all forms of meningitis, independently of the etiologic factors, occur more often in males. Meningococcic meningitis he thinks is found $1\frac{1}{2}$ times more often in males than in females. Purulent and tuberculosis meningitis also occur in the two sexes in the above proportion. Kempf *et al.* (1933) in the Indianapolis epidemic of meningococcic meningitis found even a higher ratio, 80 per cent of their cases being males.

This apparent liability of the meninges of the males to various forms of disease is also shown by Hoffman's (1913) report. He grouped together diseases of the brain, spinal cord and meninges and in this series are included 360 males and only 140 females. Diseases of the cranial and spinal nerves were found instead in 143 males and 142 females.

Dementia praecox is the one disease in this group for which the mortality in the females is somewhat higher than in the males. But it appears that the attack rate as measured by the first admission rate, shows the reverse. Official statistics for the whole country, as well as Malzberg's (1936) report for New York State, indicate that for this condition the first admission rate to institutions is higher in males. During 1922 in the United States, the number per 100,000 population of males and females admitted with a diagnosis of dementia praecox to institutions equalled 20.3 and 15.8, respectively. This refers to white urban population only. In the white rural population the rates were 9.7 for the males and 7.4 for the females. The mortality of the persons with this condition was, however, higher in the females. During that year the deaths per 1000 under treatment equalled 27.8 for the males and 33.8 for the females.

Thus it would seem that while males are more susceptible to dementia praecox, the course of this disease is more often fatal in females.

VIII. *Skin*. The two diseases in this group showing a definite sex difference in mortality are cancer of the skin and erysipelas. That these have also a higher attack rate in the males is universally accepted, but with fairly good foundation the masculine preponderance is attributed to the influence of differences in environmental exposure.

IX. *Endocrinal system*. Deaths from the break-down of this system occur more often in females because of the frequency of deaths from diabetes and diseases of the thyroid in this sex. That the incidence of the various forms of pathologic involvement of this gland is higher in females has been accepted for some time and the findings reported substantiate the conclusions. Hoffman's data give the number of females with diseases of this gland as 368 compared to only 96 males. Ehrström (1921) and also Means (1934) note that from 2 to 8 times more females than males are affected by endemic goiter. Oleson's (1924) survey of school children in Cincinnati revealed practically the same. Studies and summaries by Bram (1936), Bell (1938), Marine (1937), Osler (1935), DuBois (1929), Kennedy (1937), and Ehrström indicate that the ratio of females to males among those affected by exophthalmic goitre, simple, and colloid goitre ranges between 3 and 10 to 1. A ratio of the same magnitude is reported by DuBois, Marine, and Ehrström in relation to myxoedema.

Diabetes is another disease for which the female mortality is higher. This, according to some students [cf. Drolet (1933)] is really a recent phenomenon and to it there corresponds an increase in the number of cases treated. Joslin (1935)

notes that until 1922 his patients comprised 55 per cent males, while after that date only 45 per cent of them were males. In De Porte's survey in 1927 a similar female preponderance was found; of 505 cases with diabetes reported, 332 were in women.

This examination of the reported incidence of certain diseases in the two sexes indicates that, on the whole, the sex frequency with which certain diseases are encountered in clinical practice corresponds to the sex differences in mortality. It is to be understood that these data refer to incidences of conditions so severe as to force the persons to have recourse either to a physician or a clinic. The significance of the findings would be then that on the whole there is none or little difference between the sexes in relation to the fatality from certain diseases once the disease process has reached a severe or moderately severe stage. However, what is desired to know is whether given an equal opportunity to acquire the disease the two sexes differ in their resistance to the pathological action. The relatively meager data bearing on this point are very suggestive. Sydenstricker (1928) in his report on the morbidity survey of the people of Hagerstown, from 1921 to 1924 brought out the important fact that taking all causes and all ages together the annual illness rate was 30 per cent higher in females than in males. Considering the separate groups of diseases he found that the females demonstrated a higher sickness rate from general diseases and from diseases of the respiratory tract, nervous system, eyes and ears, circulatory system and kidneys, digestive system, non-venereal reproductive, and, of course, from puerperal conditions. The males, instead, had higher rates from epidemic, endemic and infectious diseases, diseases of the skin, and accidents. Taking age in-

to account the higher female morbidity rate was observed only after the age of ten while below that age the sickness rates were higher in the males. Furthermore, in children and adolescents Sydenstricker's data indicate that in the age periods when the males have a higher morbidity rate, it is due to existence of a larger moiety of boys who are frequently ill while in the later years, higher morbidity of the females is due both to a greater number of sick persons as well as to a larger moiety of females who are sickly or frequently ill.

Findings similar to these result from the morbidity survey of 9000 families discussed in the very recent report by Collins (1940). The population canvassed is constituted of families in 18 states kept under observation for a period of 12 consecutive months. Collins's data show that on the whole when all causes of sickness are considered the females have sickness rate (cases per 1000) almost 30 per cent higher than the males and although the exclusion of causes associated with genital and puerperal diseases reduced this excess, the female rates were still almost 20 percent higher than the males. The difference between the sexes is particularly noticeable during the adult period and in fact is not of much consequence during childhood. In terms of the diseases for which the sex differences are in evidence the females have a particularly high excess from respiratory, nervous, degenerative, and digestive diseases and rheumatism and related diseases. There is very little difference between the sexes relative to ear and mastoid diseases and skin diseases. On the other hand, the males have a definitely higher sickness rate from accidental causes.

These two sets of observations made at different periods and on different groups deserve particular attention. They indicate that with the exception of accidents

the females have after childhood as much or more sickness than the males. Since the information concerning incidence of the single disease entities in the persons surveyed is not given in sufficient detail to permit comparison with the clinical morbidity and mortality experience described above it cannot be determined whether the illnesses acquired by these persons during the period of observation are the same as those that cause death. If it is assumed that the factors involved in the sickness surveyed might also have brought about the fatal break-down of a particular organ then there would be some basis to conclude that the higher mortality of one or the other sex from the causes noted above is due to inferior resistance or recuperative power.

SUMMARY AND DISCUSSION

On the basis of official vital statistics and clinical reports some of the characteristics of the differences in the mortality and morbidity between men and women have been examined. As is well known, the males have a higher mortality throughout practically the whole life span including foetal life, or at least the latter part of it, as well. Demographers and biologists have always been aware of this phenomenon and among the hypotheses advanced to explain it the social and the narrow constitutional viewpoints represent the two extremes.

Considering the whole life span of man, it appears that the difference between the mortality of the males and of the females is greatest in early infancy, including the foetal period probably, decreases to a minimum during childhood and adolescence and increases thereafter. This trend suggests that the higher male mortality in utero and infancy results from the selective process of death which removes the weaker individuals among whom the

males predominate. After this elimination, during childhood, the mortality of the two sexes become about equal. Subsequently, the social function of the male which is accompanied by greater exposure to risks of various sorts might at least partly account for the sex differences in later years. This may well be the basic pattern underlying the phenomenon under discussion but an inquiry into the causes that lead to death reveals that either insufficient knowledge of the factors which contribute to mortality greatly obscure this fundamental pattern, or else that it does not constitute a real explanation of the sex differences. From the analysis of the relative frequency with which the males and females succumb to certain disease entities emerges a fact of the utmost importance to a clear understanding of this phenomenon. It is shown that while for some fatal diseases the males have a higher mortality, for others the females prevail, and for still others there is no appreciable differences between the death rates of the two sexes. During the foetal period males predominate with regard to deaths due to prematurity, diseases of placenta and membranes, asphyxia, prolapse and compression of cord, malpresentation and difficult labor. After birth, they have a higher mortality from angina pectoris, diseases of the coronary arteries, arteriosclerosis, myocarditis, lobar pneumonia, pleurisy, respiratory tuberculosis, rickets, osteomyelitis, tuberculosis of bones and joints, diarrhea and enteritis, duodenal and stomach ulcer, cirrhosis of the liver, appendicitis, cancer of the buccal cavity, digestive tract and skin, tabes dorsalis, general paresis, meningitis (all forms), alcoholism, suicide and accidents. Females have a higher foetal mortality from malformations and a higher post-natal death rate from whooping cough, acute rheumatic fever, chronic rheumatism,

pellagra, biliary calculus, diabetes, other diseases of the gall-bladder and pancreas besides these mentioned, and exophthalmic and simple goitre. For the diseases listed here, the greater mortality of one or the other sex occurs throughout the whole life span or throughout the age period when they, the diseases, occur primarily. The age pattern in sex differences might therefore be explained entirely on the basis of the age prevalence of the particular disease for which a sex difference exists. In the light of these findings it must be concluded that neither of the sexes demonstrates a general superior vitality but that each possesses a greater liability to specific and separate fatal conditions.

When the available data on the morbidity of the two sexes are examined it is found that hospital and clinical statistics indicate that the prevalence of the above diseases, respectively, in the males and females corresponds to the relative incidence of the mortality. On the other hand, from surveys made of the general population it appears that on the whole and with the exception of accidents a higher sickness rate is found in the females. One is led then to the conclusion that in general morbid processes, mild and grave, attack the females with greater intensity than the males.

It is not, however, definitely known whether the grave morbid processes—those that bring about the fatal breakdown of an organ-system—occur actually more frequently in the females than in the males. If they do, then the higher female mortality from the conditions specified is an expression of an increased exposure to risk, while the higher male mortality from the other conditions noted indicate an inferior degree of resistance. In this case it would be concluded that the females show a higher recuperative power. If,

instead, for the severe conditions the incidence in the males and females corresponds to that of mortality there is no basis to declare that one or the other sex has inferior resistance but the differences in mortality must be attributed to a difference in liability to the disease processes, either due to the constitutional organization or to the environment or both.

In all events it is on these fatal conditions for which a difference between the sexes is noted and on the possible elements involved that the attention must be directed. The social behavior, differing as it does between the two sexes is obviously a factor of the utmost importance. Its effects on the mortality from accidents are unquestionable and are also accepted relative to cancer of the skin. The peculiar social function of the male may probably be responsible for some of the excess male mortality from alcoholism and suicide and also from duodenal and stomach ulcer as well as from appendicitis and from acute infections such as pneumonia.

The direct influence of the structural and functional differences of the primary and secondary sex organs on the mortality of the two sexes is also a factor of great importance. Among its principal manifestations are, of course, the morbidity and mortality associated with pregnancy. In addition, the liability to certain urinary diseases is also associated with the shape of the genitalia. Another manifestation of the differences in mortality between the males and females that can be attributed to the differences in the function of the sex organs is probably the higher fatality of the females from diseases of the thyroid and other endocrine glands, all of which are intimately related to the gonads. In this respect, the well-known effects of sex hormones on the experimental production of mammary cancer need not be

emphasized. Even more significant when completely confirmed are the observations recently reported by Campbell (1939) concerning sex hormones and infections. Ordinarily, the degree of infection by *Cysticercus crassicolis* is in the female rats from 60 to 80 percent of that found in the males. By injecting theelin Campbell apparently increased the resistance of the male to equal that of the female, while in the latter no change was noted, on the average. The results were reversed when testosterone propionate was administered to rats of the two sexes.

Finally, between the males and females, there is the element of difference which is the resultant of their respective and distinctive constitutions, and is expressed by diversity in rate of metabolism, as Riddle (1932) has repeatedly shown and emphasized, and in rate and pattern of organic growth. The fact, as has been pointed out above, that in certain instances diseases of different etiology but causing a break-down of the same organ all tend to have the same type of sex difference, i.e. either a higher or a lower masculinity, suggest that the developmental factor may play a more important part than is generally recognized, particularly in relation to heart disease. One is encouraged in such a view by the results of the investigation of Klein and Palmer (1938) on the differences in the rate of dental caries among boys and girls. These authors found that at equal chronological ages girls experience more dental caries than boys. On the other hand, the eruption of permanent teeth also occurs earlier in girls so that the authors were moved to inquire whether at equal tooth age girls still have a higher caries rate. When the caries rate was actually computed in this fashion, no appreciable diversity in caries incidence would be detected between the boys and girls. Therefore, the authors conclude

that the girls have an apparently higher caries rate simply because their teeth have a longer exposure to risk. Bearing on this point it should be recalled that the growth of the majority of organs proceeds at a rate and with characteristics that are not the same in males and females, and that this is a phenomenon limited not only to man.

In conclusion, the fact that the males and females—two groups of individuals who in general differ in somatic as well as in physiological attributes—exhibit diverse reactions to pathogenic conditions not because of one but for a variety of reasons opens the way to investigate in a

comprehensive manner the fundamental factors responsible for the individual variation in susceptibility and resistance to pathogenic processes. Since in other animals besides man sex differences in mortality are to be observed and since for other animals also there exist behavioristic as well as physiological diversities between the males and females, it would seem that a deeper study of the sex differences in mortality and morbidity approached either through animal or human biology would serve to contribute a more precise evaluation of the fundamental factors involved in health and disease.

LIST OF LITERATURE

- ALLEN, E. V. 1934. The relationship of sex to disease. *Ann. Int. Med.*, Vol. 7, pp. 1000-1012.
- AUERBACH, E. 1912. Das wahre Geschlechtsverhältnis des Menschen; ein Versuch, zu seiner Berechnung. *Arch. f. Rassen-u. Gesellsch.-Biol.*, Bd. 9, pp. 10-17.
- AUSTRIAN, C. R. 1939. Acute lobar pneumonia. In *Practice of Medicine*, edited by F. Tice. Vol. 3. Hagerstown (W. F. Prior Co.).
- BARACH, A. L. 1933. Diseases of the lungs. In *The Practitioners Library of Medicine and Surgery*. Vol. 3. New York (D. Appleton and Co.).
- BELL, E. T. 1938. A Text-book of Pathology. Philadelphia (Lea and Febiger).
- BOLDRINI, M. 1930. Sulla proporzione dei sessi nei concepimenti e nelle nascite. *Università Cattolica del Sacro Cuore. Contributi del Laboratorio di Statistica, Ser. Prima*, pp. 213-287.
- BOYD, W. 1938. A Text-book of Pathology. Philadelphia (Lea and Febiger).
- BRAM, I. 1936. Exophthalmic Goiter and Its Medical Treatment. St. Louis (C. V. Mosby Co.).
- BRIDGES, C. B. 1932. The genetics of sex in *Drosophila*. In *Sex and Internal Secretions*, edited by Edgar Allen. Baltimore (Williams & Wilkins Co.).
- . 1939. Cytological and genetic basis of sex. In *Sex and Internal Secretions*, edited by Edgar Allen. Baltimore (Williams & Wilkins Co.).
- BRITISH MEDICAL RESEARCH COUNCIL. 1938. Epileptics in Schools. London (His Majesty's Stationery Office).
- BROOKS, H. 1929. Angina pectoris. In A Text-book of Medicine, edited by R. L. Cecil. Philadelphia and London (W. B. Saunders Co.).
- BROWN, T. R. 1929. Peptic ulcer. In A Textbook of Medicine, edited by R. L. Cecil. Philadelphia and London (W. B. Saunders Co.).
- BUNDESEN, H. B., W. I. FISHER, O. A. DAHMS, and E. L. POTTER. 1937. Factors responsible for failure further to reduce infant mortality. *Jour. Amer. Med. Assoc.*, Vol. 109, pp. 337-343.
- BYERLEY, T. C., and M. A. JULL. 1935. Sex ratio and embryonic mortality in domestic fowl. *Poultry Sci.*, Vol. 8, pp. 230-234.
- CAMPBELL, D. H. 1939. The effect of sex hormones on the normal resistance of rats to *Cysticercus crassicolis*. *Science*, Vol. 89, pp. 415-416.
- CECIL, R. L. 1937. Lobar pneumonia. In A Text-book of Medicine, edited by R. L. Cecil. London (W. B. Saunders Co.).
- CHRISTIAN, H. A. 1935. The Diagnosis and Treatment of Diseases of the Heart. New York (Oxford University Press).
- CIOCCO, A. 1936a. The historical background of the modern study of constitution. *Bull. Inst. of the Hist. Med., Johns Hopkins University*, Vol. 4, pp. 23-38.
- . 1936b. Studies on constitution. III. Somatological differences associated with diseases of the heart in white females. *Human Biology*, Vol. 8, pp. 38-91.
- . 1938a. Variation in the sex ratio at birth in the United States. *Human Biology*, Vol. 10, pp. 36-64.
- . 1938b. The masculinity of stillbirths and

- abortions in relation to the duration of uterogestation and to the stated causes of foetal mortality. *Human Biology*, Vol. 10, pp. 235-250.
- COLE, L. J., and F. KIRKPATRICK. 1915. Sex ratio in pigeons together with observations on the laying, incubation and hatching of the eggs. *R. I. Agr. Exp. Sta. Bull.*, No. 162, pp. 463-512.
- COLLINS, S. D. 1940. Cases and days of illness among males and females, with special reference to confinement in bed. *Pub. Health Rep.*, Vol. 55, pp. 47-93.
- COOMBS, C. F. 1924. Rheumatic Heart Disease. *New York* (W. Wood and Co.).
- COWAN, J., and W. T. RITCHIE. 1935. Diseases of the Heart. *Baltimore* (W. Wood and Co.).
- CREW, F. A. E. 1923. Studies in intersexuality. Part II. Sex-reversal in the fowl. *Proc. Roy. Soc.*, Vol. 95, pp. 256-280.
- 1925. Prenatal death in the pig and its effect upon the sex ratio. *Proc. Roy. Soc. Edinburgh*, Vol. 46, pp. 9-14.
- 1937. The sex ratio. *Amer. Nat.*, Vol. 71, pp. 529-559.
- 1938. The sex ratio of the domestic fowl and its bearing upon the sex-linked theory of differential mortality. *Proc. Roy. Soc. Edinburgh*, Vol. 58, pp. 73-79.
- DANFORTH, C. H. 1932. The interrelation of genic and endocrine factors in sex. In *Sex and Internal Secretions*, edited by Edgar Allen. *Baltimore* (Williams & Wilkins Co.).
- 1939. Relation of genic and endocrine factors in sex. In *Sex and Internal Secretions*, edited by Edgar Allen. *Baltimore* (Williams & Wilkins Co.).
- DEPARTMENT OF COMMERCE, BUREAU OF THE CENSUS. 1926. Patients in Hospitals for Mental Disease, 1923. *Washington, D. C.* (Gov't. Printing Office).
- DEPORTE, J. V. 1929. Sickness in rural New York. *Jour. Amer. Med. Assoc.*, Vol. 92, pp. 522-528.
- 1933. Heart disease in general medical practice. *Amer. Heart Jour.*, Vol. 8, pp. 476-489.
- DROLET, G. J. 1933. Diabetes mortality, New York City. *Jour. Amer. Med. Assoc.*, Vol. 100, pp. 733-735.
- DUBLIN, L. I., and A. J. LOTKA. 1936. Length of Life. *New York* (The Ronald Press).
- DUBOIS, E. F. 1929. Disease of the thyroid gland. In *A Textbook of Medicine*, edited by R. L. Cecil. *Philadelphia and London* (W. B. Saunders Co.).
- EGGLESTON, C. 1929. Diseases of the myocardium. In *A Textbook of Medicine*, edited by R. L. Cecil. *Philadelphia and London* (W. B. Saunders Co.).
- ENESTRÖM, R. 1921. Susceptibility of the sexes to disease. *Finska Läkaresällskapets Handlingar*. Abstracted in *Jour. Amer. Med. Assoc.*, Vol. 76, p. 1288.
- EUTERMAN, G. B., and D. C. BALFOUR. 1936. The Stomach and Duodenum. *Philadelphia* (W. B. Saunders Co.).
- FARR, W. 1885. Vital Statistics. *London* (Office of the Sanitary Institute).
- FROST, W. H. 1919. The epidemiology of influenza. *Pub. Health Rep.*, Vol. 34, pp. 1823-1836.
- GEISER, S. W. 1921. Notes on the differential death-rate in *Gambusia*. *Ecology*, Vol. 2, pp. 220-222.
- 1923. Evidences of a differential death-rate of the sexes among animals. *Amer. Mid. Nat.*, Vol. 8, pp. 153-163.
- GLOVER, J. A. 1928. A report on chronic arthritis. *Ministry of Health, Repts. on Publ. Health and Med. Subj.*, No. 52, pp. (of reprint) 103.
- GODFREY, E. S. 1928. Epidemiology of whooping cough. *New York State Jour. Med.*, Vol. 18, pp. 1410-1415.
- GÖRHLERT, V. 1888. Die Schwankungen der Geburtenzahl nach Monaten. *Biol. Centralbl.*, Vol. 8, pp. 342-352.
- GOLDBERGER, J., G. A. WHEELER, E. SYDENSTRICKER, and W. I. KING. 1929. A Study of Endemic Pellagra in Some Cotton-mill Villages of South Carolina. *U. S. Hygienic Laboratory Bulletin* No. 153. *Washington* (Gov't. Printing Office).
- GOLDSCHMIDT, R. 1917. Intersexuality and the endocrine aspect of sex. *Endocrinology*, Vol. 1, pp. 433-456.
- 1938. Intersexuality and development. *Amer. Nat.*, Vol. 72, pp. 228-242.
- GOODRIDGE, M. 1929. Thrombo-angiitis obliterans. In *A Textbook of Medicine*, edited by R. L. Cecil. *Philadelphia and London* (W. B. Saunders Co.).
- GRAUNT, J. 1676. Natural and Political Observations. *London* (J. Martyn).
- GRIFFITH, J. P. C., and A. GRAEME MITCHELL. 1937. The Diseases of Infants and Children. *Philadelphia* (W. B. Saunders Co.).
- HAIG-THOMAS, R., and J. S. HUXLEY. 1927. Sex ratio in pheasant species-cross. *Jour. Genetics*, Vol. 18, pp. 233-246.
- HEMPELMANN, T. C. 1935. Diseases of the stomach. In *The Practitioners Library of Medicine and Surgery*. Vol. 7. *New York* (D. Appleton and Co.).
- HERTWIG, R. 1906. Weitere Untersuchungen über das Sexualitätsproblem. *Verh. deut. Zool. Gesellsch.*, Bd. 16, pp. 90-112.

- HARR, A. E. 1929. Rickets, Including Osteomalacia and Tetany. *Philadelphia* (Lea and Febiger).
- HILL, A. B. 1933. Some aspects of the mortality from whooping cough. *Jour. Roy. Stat. Soc.*, Vol. 96, pp. 240-285.
- HOFFMAN, F. L. 1913. The Statistical Experience Data of the Johns Hopkins Hospital, Baltimore, Md., 1892-1911. *Baltimore* (The Johns Hopkins Press).
- HOLMES, S. J. 1926. The sex ratio in infant mortality as an index of a selective death rate. *Univ. of Calif. Publ. in Zool.*, Vol. 29, pp. 267-303.
- , and V. P. MERTZER. 1931. Changes in the sex ratio in infant mortality according to age. *Human Biology*, Vol. 3, pp. 560-575.
- HOOB, K., and W. C. ALVAREZ. 1930. The influence of sex on the incidence of gastrointestinal disease. *Human Biology*, Vol. 2, pp. 63-98.
- JEWELL, F. M. 1921. Sex ratios in foetal cattle. *Biol. Bull.*, Vol. 41, pp. 259-271.
- JOSLIN, E. P. 1935. The Treatment of Diabetes Mellitus. *Philadelphia* (Lea and Febiger).
- KEMPF, G. F., L. H. GITMAN, and L. G. ZERFAS. 1933. Meningococcus meningitis and epidemic meningo-encephalopathy. *Arch. Neur. and Psych.*, Vol. 29, pp. 433-453.
- KENNEDY, R. L. J. 1937. The thyroid gland. In *Practice of Pediatrics*, edited by J. Brennemann. Vol. 1. *Hagerstown* (W. F. Prior Co.).
- KING, H. D. 1921. A comparative study of the birth mortality in the Albino rat and in man. *Anat. Rec.*, Vol. 20, pp. 321-354.
- KLEIN, H., and C. E. PALMER. 1938. Sex differences in dental caries experience by elementary school children. *Publ. Health Repts.*, Vol. 53, pp. 1685-1690.
- LAING, J. S., and M. HAY. 1901. Whooping cough: its prevalence and mortality in Aberdeen. *Publ. Health*, Vol. 14, pp. 584-599.
- LANDAUER, W., and A. B. LANDAUER. 1931. Chick mortality and sex ratio in domestic fowl. *Amer. Nat.*, Vol. 65, pp. 492-501.
- LEBLANC, T. J. 1925. Venereal Disease Incidence at Different Ages in Certain Southern States. *U. S. Public Health Venereal Dis. Bull.* No. 78. *Washington* (Gov't. Printing Office).
- LENZ, F. 1931. Morbific hereditary factors. In *Human Heredity*, by E. Baur, E. Fischer and F. Lenz. *New York* (Macmillan Co.).
- LEVINSON, A. 1937. Meningitis. In *Practice of Pediatrics*, edited by J. Brennemann. Vol. 4. *Hagerstown* (W. F. Prior Co.).
- LEWIS, D. 1929. Acute appendicitis. In *A Textbook of Medicine*, edited by R. L. Cecil. *Philadelphia and London* (W. B. Saunders Co.).
- LITTLE, C. C. 1919. Some factors influencing the human sex-ratio. *Proc. Soc. Exp. Biol. and Med.*, Vol. 16, pp. 127-130.
- MACARTHUR, S. W., and W. H. T. BAILLIE. 1932. Sex differences in mortality in *Abraxas*-type species. *QUART. REV. BIOL.*, Vol. 7, pp. 313-325.
- MCCANN, W. S. 1934. Diseases of the urinary tract. In *Internal Medicine*, edited by J. H. Musser. *Philadelphia* (Lea and Febiger).
- MALZBERG, B. 1936. Trends of mental disease in New York state. *Psychiat. Quart.*, Vol. 9, pp. 667-707.
- MARINE, D. 1937. The thyroid gland. In *Practice of Medicine*, edited by F. Tice. Vol. 8. *Hagerstown* (W. F. Prior Co.).
- MEANS, J. H. 1934. Diseases of the endocrine glands. In *Internal Medicine*, edited by J. H. Musser. *Philadelphia* (Lea and Febiger).
- MINOT, G. R., T. E. BUCKMAN, and R. ISAACS. 1924. Chronic myelogenous leukemia. *Jour. Amer. Med. Assoc.*, Vol. 82, pp. 1489-1494.
- MORRIS, R. S. 1929. Acute fibrinous pericarditis. In *A Textbook of Medicine*, edited by R. L. Cecil. *Philadelphia and London* (W. B. Saunders Co.).
- MUSSER, J. H. 1934. Diseases of nutrition. In *Internal Medicine*, edited by J. H. Musser. *Philadelphia* (Lea and Febiger).
- NEWCOMB, S. 1904. The Probability of Causes of the Production of Sex in Human Offspring. *Washington* (Carnegie Institution of Washington).
- NICIFORO, A. 1924. Lezioni di Demografia. *Naples* (G. Majo).
- OLESON, R. 1924. Thyroid survey of 47,493 elementary-school children in Cincinnati. *U. S. Publ. Health Repts.*, Vol. 39, pp. 1777-1802.
- OSLER, W. 1935. The Principles and Practice of Medicine. *New York* (D. Appleton-Century Co.).
- PARKES, A. S. 1925. Studies on the sex-ratio and related phenomena. (7) The foetal sex-ratio in the pig. *Jour. Agricul. Sci.*, Vol. 15, pp. 285-299.
- . 1926. The mammalian sex-ratio. *Biol. Rev.*, Vol. 2, pp. (of reprint) 51.
- PEARL, R. 1917. The sex ratio in the domestic fowl. *Proc. Amer. Phil. Soc.*, Vol. 56, pp. 416-436.
- . 1920. Certain evolutionary aspects of human mortality rates. *Amer. Nat.*, Vol. 54, pp. 5-44.
- . 1922. The Biology of Death. *Philadelphia and London* (J. B. Lippincott Co.).
- . 1928. The Rate of Living. *New York* (A. A. Knopf).

- , and A. Crocco. 1934. Studies on constitution. II. Somatological differences associated with diseases of the heart in white males. *Human Biology*, Vol. 6, pp. 650-713.
- PELSENER, P. 1925. La proportion relative des sexes chez les animaux. *Acad. Roy. de Belg.*, T. 8, pp. 1-258.
- PEMBERTON, R. 1929. Chronic arthritis. In *A Textbook of Medicine*, edited by R. L. Cecil. Philadelphia and London (W. B. Saunders Co.).
- PFAUNDLER, M. 1936. Studien über den FrühTod, Geschlechtsverhältnis und Selektion. I. Mitteilung: Zur intrauterinen Absterbeordnung. *Zschr. f. Kinderbl.*, Bd. 57, pp. 185-227.
- QUETELET, A. 1835. *Essai de Physique Sociale*. Paris (Bachelier).
- RIDDLE, O. 1927. Some aspects of sexual differences in prenatal growth and death. *Amer. Nat.*, Vol. 61, pp. 97-112.
- . 1930. New data on the relation of metabolism to sex. *Proc. 2nd Internat. Congress Sex Res.*, pp. 180-189.
- . 1931. Factors in the development of sex and secondary sexual characteristics. *Physiol. Rev.*, Vol. 11, pp. 63-103.
- . 1932. Metabolism and sex. In *Sex and Internal Secretions*, edited by Edgar Allen. Baltimore (Williams & Wilkins Co.).
- ROLLSTON, H. D., and J. W. McNEE. 1929. Diseases of the Liver, Gall-bladder and Bile-ducts. London (Macmillan and Co.).
- SCHULTZ, A. H. 1921. Sex incidence in abortions. *Contributions to Embryology*, Vol. 12, Carnegie Inst. Wash. Pub. No. 56, pp. 177-193.
- SMITH, F. M. 1934. Diseases of the heart. In *Internal Medicine*, edited by J. H. Musser. Philadelphia (Lea and Febiger).
- SPAULDING, M. H. 1921. The development of the external genitalia in the human embryo. *Contributions to Embryology*, Vol. 13, Carnegie Inst. Wash. Pub. No. 276, pp. 69-88.
- SPRAGUE, H. B. 1937. Coronary artery disease and coronary occlusion. In *Nelson's Medicine*, Vol. 4. New York (Thomas Nelson and Sons).
- STALLYBRASS, C. O. 1931. The Principles of Epidemiology and the Process of Infection. London (G. Routledge and Son).
- STENGER, A., and R. A. KERN. 1922. Diseases of the liver and gall-bladder. In *Nelson's Medicine*. Vol. 5. New York (Thomas Nelson and Sons).
- STREETER, G. L. 1920. Weight, sitting height, head size, foot length, and menstrual age of the human embryo. *Contributions to Embryology*, Vol. 11, Carnegie Inst. Wash. Pub. No. 274, pp. 143-170.
- SWIFT, H. F. 1937. Rheumatic fever. In *A Textbook of Medicine*, edited by R. L. Cecil. Philadelphia and London (W. B. Saunders Co.).
- SYDENTRICKER, E. 1928. Sex differences in the incidence of certain diseases at different ages. *Publ. Health Repts.*, Vol. 43, pp. 1259-1276.
- SYDENTRICKER, V. P. 1934. Diseases of doubtful etiology. In *Internal Medicine*, edited by J. H. Musser. Philadelphia (Lea and Febiger).
- THOMSON, J., and L. FINDLAY. 1933. The Clinical Study and Treatment of Sick Children. London (Oliver and Boyd).
- TORREY, R. G. 1934. Diseases of the locomotor system. In *Internal Medicine*, edited by J. H. Musser. Philadelphia (Lea and Febiger).
- . 1935. Rheumatic fever. In *Practice of Medicine*, edited by F. Tice. Vol. 2. Hagerstown (W. F. Prior Co.).
- TRASK, J. D. 1937. Pneumonia and bronchitis. In *Practice of Pediatrics*, edited by J. Brennemann. Vol. 2. Hagerstown (W. F. Prior Co.).
- TSCHUPROW, A. A. 1915. Zur Frage des sinkenden Knabenüberschusses unter den ehelichen Geborenen. (Zugleich ein Beitrag zur Statistik der Fehl- und Totgeburten.) *Bull. Inst. Internat. de Statist.*, T. 20, pp. 378-492.
- TURNER, T. B. 1930. Race and sex distribution of lesions of syphilis in 10,000 cases. *Bull. Johns Hopkins Hosp.*, Vol. 46, pp. 159-184.
- VANDERHOOF, D. 1929. Pellagra. In *A Textbook of Medicine*, edited by R. L. Cecil. Philadelphia and London (W. B. Saunders Co.).
- VAUGHAN, W. T. 1921. Influenza. An Epidemiological Study. *Amer. Jour. Hyg.*, Monographic Series. Baltimore (Amer. Jour. of Hygiene).
- WHITE, P. D. 1937. Heart Disease. New York (Macmillan Co.).
- WIBHL, D. G. 1938. Sex differences in mortality in the United States. *Milbank Mem. Fund. Quart.*, Vol. 16, pp. 145-155.
- WILSON, K. M. 1926. Correlation of external genitalia and sex glands in the human embryo. *Contributions to Embryology*, Vol. 18, Carnegie Inst. Wash. Pub. No. 91, pp. 23-30.
- WILSON, M. G., C. LINGG, and G. CROXFORD. 1928. Statistical studies bearing on problems in the classification of heart disease. III. Heart disease in children. *Amer. Heart Jour.*, Vol. 4, pp. 164-196.
- WYCKOFF, J., and C. LINGG. 1926. Statistical

- studies bearing on problems in the classification of heart diseases. II. Etiology in organic heart disease. *Amer. Heart Jour.*, Vol. 1, pp. 446-470.
- WYLLIE, J. 1933. Sex differences in infant mortality. *Canad. Publ. Health Jour.*, Vol. 24, pp. 177-185.
- WILLIAMS, B. H. 1939. Embryonic development of sex. In *Sex and Internal Secretions*, edited by Edgar Allen. Baltimore (Williams & Wilkins Co.).
- WITACHI, E. 1934. Genes and inductors of sex differentiation in amphibians. *Biol. Rev.*, Vol. 9, pp. 460-488.
- . 1939. Modification of development of sex in lower vertebrates and in mammals. In *Sex and Internal Secretions*, edited by Edgar Allen. Baltimore (Williams & Wilkins Co.).
- YOUNG, M., and W. T. RUMBLE. 1927. Sexual differentiation in susceptibility to and mortality from whooping-cough in children under 5 years. *Brit. Jour. Children's Dis.*, Vol. 24, pp. 165-184.
- ZIMMERMAN, H. M. 1937. Deficiency diseases and the nervous system. In *Practice of Medicine*, edited by F. Tice. Vol. 10. Hagerstown (W. F. Prior Co.).



PHYSIOLOGY AND THE ORIGINS OF THE MENSTRUAL PROHIBITIONS

By M. F. ASHLEY-MONTAGU

Department of Anatomy, Habnemann Medical College, Philadelphia, Pennsylvania

THE conception of the nature of menstruation and the prohibitions which are usually associated with it are remarkably similar in almost all human groups. Whether this may be taken as yet another illustration of the uniformity of the human mind, or alternatively, as evidence of a complex of beliefs having some common cultural origin, it is unnecessary to inquire here. Briefly, the menstrual discharge is most generally conceived to be a peculiarly noxious effluvium which automatically renders everything unclean with which it comes into contact. That being so, the female during her catamenial flow is considered to be herself unclean and as noxious as the effluvium itself. She is therefore usually segregated until the cessation of the catamenia or until some prescribed time following its termination, whenafter she customarily undergoes a ritual cleansing or purgation, following which she may once more resume a normal social life among her people. Anything she may have touched during the catamenia must either be destroyed or purified. Detailed discussions of the folkloristic and related aspects of this subject are to be found in the works of Briffault (7), Ellis (13), Frazer (19), Lévy-Bruhl (34), Ploss, Bartels, and Bartels (45), and Westermarck (57). In *The Old Testament* may be found the type expression of these beliefs and practises. One may here recall the first verse from *Leviticus*,

Chapter 15, Verses 19 to 33: "And if a woman have an issue, *and* her issue in her flesh be blood, she shall be put apart seven days: and whosoever toucheth her shall be unclean until the even." (33).

An old rhyme puts this viewpoint very neatly:

"Oh! menstruating woman, thou'rt a fiend
From which all nature should be closely
screened."

This charming rhyme is quoted without statement of source in a work by Milne (42). It would be of some interest to know its origin.

In *The Natural History* Pliny (44) interestingly presents the Roman viewpoint. He writes:

It would indeed be a difficult matter to find anything which is productive of more marvelous effects than the menstrual discharge. On the approach of a woman in this state must will become sour, seeds which are touched by her become sterile, grafts wither away, garden plants are parched up, and the fruit will fall from the tree beneath which she sits. Her very look, even, will dim the brightness of mirrors, blunt the edge of steel, and take away the polish from ivory. A swarm of bees, if looked upon by her, will die immediately; brass and iron will instantly become rusty, and emit an offensive odour; while dogs which may have tasted of the matter so discharged are seized with madness, and their bite is venomous and incurable.

Elsewhere in the same work Pliny (44) repeats what he terms the "ravings", and which we may term the superstitions, of his age "of a most dreadful and un-

utterable nature" relating to the remedial and miraculous effects of which the menstrual discharge was supposed to be capable.

These, indeed, are for the most part nothing but ravings, and we need not consider them here except to say that a large number of the beliefs that Pliny describes may be found still persisting today in many parts of Europe as well as in many other regions of the world. An extremely large number of superstitions are associated with menstruation, and one of the most deeply entrenched of these which has for many generations enjoyed the status of a demonstrated truth, namely, the relation of the catamenia to the lunar cycle, has only very recently been shown, by Gunn *et al.* (23), to be totally without foundation. This demonstration, it may be added, being successfully carried out in spite of the elaborate theory of Gerson (21), an over-enthusiastic psychoanalytic writer, that menstruation probably became established as a biologico-lunar function as a consequence of the sport indulged in by primitive man of hunting his females on moonlit nights. The resulting anticipatory uterine hyperemia of the female over the course of many such moonlit nights, Gerson suggested, eventually developing into the overt bleeding of menstruation!

One of the oldest beliefs concerning menstruation is that the touch of a menstruous woman is capable of causing flowers and other plants to wilt and wither, preserves of every sort to spoil, dough to fail to rise, seeds to become sterile, meat to decompose, and so on. In many parts of Europe menstruous women are excluded from certain occupations. In the great French perfumeries, for example, women are not permitted to work during the time of their menstruation; nor are they allowed to pick mushrooms in those

regions in which their growth is a profitable industry. In the south of France at such times they are not allowed to tend silkworms, and in the various wine districts of France and also of the Rhine women are debarred from approaching or handling the vessels in which fermentation takes place for the reason that should their courses begin, fermentation would be accelerated and the wine spoilt. For similar reasons, according to Laurent (31), women are excluded from the sugar refineries of northern France. The prohibition with respect to the handling of wine is incidentally clearly stated in the *Talmud* (*Midrash Wayyiqra*) in the tale of Rabbi Gamliel and the maid-servant Fabritha. In this connexion the subject is discussed by Wünsche (59), and referred to by Spivak (54).

That women are physiologically in a peculiar state during the catamenia must have been fairly obvious from the earliest times; apart from the subjective evidences apparent to the woman herself, there are the important occasional mental disturbances, the so-called menstrual psychoses. There is some evidence that these mental disturbances have played a significant part in determining particular cultural viewpoints relating to the menstruous woman. Vidoni (56), for example, reports the record of a mediaeval Council which actually met to discuss the question as to whether or not a woman was to be held responsible for her actions during the catamenia. Tuttle (55) has experimentally shown that women undergo significant changes in irritability during menstruation. Novak (43), who has reviewed the evidence, points out that epileptiform states have frequently been found to coincide with or even to replace the catamenia. The association of menstruation with certain forms of hysteria is clinically well known. This associa-

tion is, of course, of considerable interest in our present connexion, and it may be recalled that the ancient belief that hysteria originated in some affection of the womb is epitomized in the very word *hysteria*, which is derived from the Greek word for womb, namely *hystera*. Malodorous breath, increase in amount of sweat and its odour, skin eruptions of various kinds, respiratory disorders, among many other conditions which one may find reviewed in such a standard gynecological treatise as that by Graves (22), represent some of the well-known changes which occur during the menstrual period. Such conditions form a good foundation for believing almost anything of the menstruous woman, and would certainly lend some support to the suggestion that at such times she is capable of exerting a noxious influence upon the objects with which she comes into physical contact. The changes which occur within the female during menstruation are not by any means fully understood, but recently Bartelmez (4) in an admirable paper, which inspired the present paper, has reviewed some of the physiological theories and investigations relating to the alleged effects of menstruous women upon various living tissues. Bartelmez appears to have been the first scientist to have taken this matter seriously enough to make an attempt to bring the relevant evidence together. Unquestionably many of the conditions attributed to the menstruous woman are purely mythological, but the important point is that some of them are not, and it is not always easy to disentangle the true from the false. Something of the difficulty is illustrated by a recent experience of the present writer who, during his inquiries into this subject, was independently informed by a number of cultured women that many "beauticians" advise against a visit to the beauty

shop during the menstrual period, because during that period a so-called permanent hair-wave will not 'take' as well as during the intermenstrual period. Satisfactory confirmation of this view could not be obtained from several beauticians consulted upon this matter. Nonetheless, it is quite possible that there may be a modicum of truth in the statements obtained from the clients of beauticians. It is well known that the bio-electric potential of the body differs from the normal conditions during menstruation, as recently shown by Burr and Musselman (8), and this, in some way, may possibly be related to the alleged menstrual hair-wave phenomenon. It is a subject which would bear investigation. However this may be, the supporting evidence for the belief in the menstruous woman's capacity for producing noxious effects upon living tissues is by no means contemptible, and in popular superstition, as well as in industrial centers in many places, the belief is, as we have already seen, solidly entrenched. Thus far these beliefs have enjoyed no more status than that which is usually granted to any folkloristic belief by those who are said to know better, but within recent years a gradually increasing body of experimentally controlled evidence has become available which renders it highly probable that there is actually a physiological basis, a foundation in fact, for these beliefs, and it has even been suggested by Macht and Davis (37) that such findings may explain the origin of the menstrual superstitions and prohibitions of primitive peoples. It is this latter possibility which it is proposed briefly to examine in this paper. Before doing so it is necessary to give an account of the kind of evidence which would appear to prove that menstruous women are capable of exerting some, at least, of the noxious effects which popular

superstition has for so long attributed to them.

It was not until as late as 1920 that Schick (51) first succeeded in arousing some scientific interest in these matters. Schick noted that various kinds of freshly cut flowers will wilt in anything from 10 to 20 minutes after handling by certain women during the first two days of the catamenia. Having found that the menstrual discharge itself exerts the same effect he postulated the excretion of a menstrual toxin or "menotoxin" during menstruation. In addition he found that systemic blood and axillary sweat during menstruation were more toxic to blossoms and retarded the growth of yeast more appreciably than at other times. Soon after Frank (18) confirmed this by placing flowers in a solution of menstruous woman's milk, and observed that the flowers wilted significantly earlier than flowers placed in a solution of non-menstruous woman's milk. This investigator very pertinently cited the prevalence of various disturbances in infants during suckling by a menstruous woman, a fact confirmed by the observations of Fraenkel (17), Silber (53), Eltz (14), and Borsarelli (6) among others. The idea of the existence of a menotoxin has found support among many clinicians for the reason, among others, as Aschner (1, 2) has pointed out, that during menstruation every organ of the body may be disturbed and every existing pathological or abnormal condition exacerbated. Sanger (50) was unable to confirm Schick's findings, but he is thus far the only investigator who has failed to do so. Levinson (32) has found that menstrual serum when injected into guinea pigs is more toxic in its effects than normal human serum. Macht and Lubin (38) obtained similar results for *Paramacia*, trypanosomes, and goldfish. Sieburg and

Patzschke (52) have observed slowing of the frog's heart beat and an increase in the intestinal tone of the rabbit when exposed to the axillary sweat of menstruous women. These investigators consider the active agent to be choline. Labhardt (29) using the same methods reports much greater variability, incidentally finding the sweat of some men as potent as that of any menstruous woman! Polano and Dietl (46) find that the growth of yeast may be retarded or accelerated after being kneaded by menstruous women. They suggest that cyclic fluctuations in the traces of choline and creatinine excreted in the sweat from the finger tips is the responsible agent. It is of interest to recall here that in the course of a discussion, which took place in the pages of *The British Medical Journal* in 1878, concerning the alleged deleterious effects exerted by menstruating women on the cure of meat, one correspondent, R. B. F., made a similar suggestion, offering as an explanation for the phenomenon "the moisture that is on the hands and body during the catamenial period" (15), a suggestion which, in the same issue of the journal, was treated with derision by the editorial writer. Both Novak (43) and Briffault (7) quote this discussion as exemplifying the persistence of such superstitions 'even' among medical men. It may be so, but as Hull (26) has remarked "The superstitions of today were the serious beliefs of yesterday, and as such they demand from us both study and respect." Klaus (27) by gravimetric determinations of choline in sweat by the platinic chloride method computes that 312 mgm. of choline per liter occurs in menstrual or immediately pre-menstrual women as compared with 6.5 mgm. in intermenstrual women, and only a trace in men. Later Klaus (28) sought, but failed, to find choline in the discharge

itself. The odour of the discharge, however, indicates trimethylamine, and tests for it during menstruation, and also it may be noted during the intermenstruum, are positive. Klaus suggests that choline eliminated during menstruation is broken down into trimethylamine or a similar substance. In this connexion it is of great interest to recall here that as long ago as 1902 Michin (41) had already shown that in normal women the quantity of trimethylamine varied between 0.07 per cent to 0.72 per cent with a mean of 0.33 per cent. In women with various genito-urinary disorders the range was from 0.00 to 0.64 per cent. Michin very significantly found that trimethylamine was altogether absent from the secretions in post-climacteric women, and moreover that it was strongly bactericidal as well as tumor-activating in its action. The present writer has elsewhere given a brief account (3) of Michin's findings. Czapek (11) has shown that trimethylamine accumulates in the sexual organs of many plants and animals; and quite recently Havas (25) has demonstrated the sex-hormone like properties of trimethylamine, as well as its bactericidal and tumor stimulating properties. Sieburg and Patschke (52) found that choline had no demonstrable effect upon cut flowers, and Macht and Lubin (38) similarly found that choline was not very toxic for various plants. Klaus (28) failed to find evidences of choline in the discharge itself, and Cattaneo (9) failed to find any traces of this substance in the human uteri examined by him. On the other hand Láncoz (30) has found that a preparation of frog's gastrocnemius muscle loses excitability when either the nerve or the muscle is held by a menstruous woman for 10 or 15 minutes, and that dilute solutions of trimethylamine have the same effect. Macht and Lubin (38) believe menotoxin

to be an oxycholesterol. These investigators found that blood serum, blood corpuscles, saliva, sweat, milk, tears, and urine of menstruous women produce inhibition of fermentation by yeast; that the mere handling of yeast by a menstruous woman is sufficient to produce wholesale destruction of these microscopic plants. They found also that these substances produce retardative and toxic effects in *Paramecia* and trypanosomes, causing withering of freshly cut flowers, inhibiting the geotropic properties of lupine seedlings, inhibiting protoplasmic streaming of certain plant cells, and generally producing a depressant effect upon plant and animal tissues. Macht and his various co-workers (35, 36, 37, 38) have repeatedly confirmed these findings in a number of studies, and these have for the most part been confirmed by a large number of other investigators. Böhmer (5) has obtained similar results by the use of the same methods and has found that similar toxic effects are produced by the menstrual discharge when the vulval secretions are included. Dogliotti (12) using the discharge obtained directly from the uterus failed to observe any effects on frog's heart or neuromuscular preparations or on arterial pressure in the dog. Mandelstamm and his co-workers (39) using the phytotoxic method found no evidence of retardation of growth of seedlings by menstrual discharge removed from the uterus, by blood, or blood serum, but they did obtain a slight effect by using the vulval discharge. Macht (35) found that menstrual serum delayed the coagulation time of dog's and human blood, and the same investigator (36) by means of a special method devised by him, a method which yields a phytotoxic index (i.e., the ratio of the growth of the roots of *Lupinus albus* seedlings immersed in a solution containing the unknown

menotoxic factor to the growth of the roots of the untreated controls), has shown that normal blood sera (derived from "several thousand" samples) in 1 per cent solution yields an average phytotoxic index of 75 per cent—complete theoretical atoxicity being taken as equal to an index of 100 per cent. Menstrual blood sera yields the high phytotoxic index of 51 per cent, an index which for toxicity is so far as is at present known exceeded only by the blood sera of the grave diseases such as pernicious anaemia, leprosy, and trachoma, with phytotoxic indices respectively of 44, 47, and 48 per cent. Meyran and Nothaas (40) have shown that any blood serum has an inhibitory effect on lupine seedlings, and observed a significant retardation from the blood only of 4 out of 23 menstruating women. Such a finding suggests the existence of significant variations as between different individuals. Freeman and Looney (20) have been unable to find any significant difference in the degrees of toxicity of menstrual and intermenstrual blood; the phytotoxic indices obtained by them on 22 normal women being respectively 53.2 and 53.9 per cent. Fleckner (16) has found that systemic blood will produce the same effect upon plants as menstrual discharge when added to the nutrient solution in which they are growing. He also finds that the discharge like the blood when added to the water used on plants growing in earth serves simply as manure. Among the most significant studies thus far carried out on the effects of menstrual discharge and saliva is that of the botanist Christiansen (10) who found that menstrual discharge from cervix uteri and vagina produced either retardation or acceleration of growth in yeast and also in the bacteria producing coagulation of milk. Christiansen also found that saliva from a

menstruous woman invariably inhibited fermentation. Important seasonal variations were observed in the effects produced by the menstrual discharge. Interestingly enough Christiansen found that an emanation from the menstrual discharge was capable both of killing and inhibiting the growth of yeast cells at a distance, and he suggests that this effect may be due to the action of mitogenetic rays. Rahn and Barnes (48) have repeated and confirmed Christiansen's work, and emphasize the probable rôle played by mitogenetic rays in the production of the observed effects. Rahn (47) has discussed this subject in some detail in a later work. Rahn and Barnes (49) found that oxycholesterol killed yeast cells through quartz, but Macht and Davis (37) were unable to obtain any effect on *Lupinus albus* seedlings when a menstruous woman's hand contained in a quartz vessel was immersed in the nutrient solution; the unprotected hand, however, when immersed in the solution for only a few minutes produced a definite inhibitory effect.

Without here entering into any discussion of the nature of the substance which is secreted by women during menstruation, and which may be the responsible agent in producing the effects upon living tissues described above, it may be said that the evidence strongly points to an alkylamine, most probably trimethylamine. It has long been popularly recognized that the characteristic odour emanating from the female vagina and that which arises from decomposing fish bear a great similarity to one another; but while the odour of decomposing fish has long been known to be due to trimethylamine the origin of the odour emanating from the human vagina has remained undetermined. Woodward and Alsberg (58) point out that the volatile alkylamines which occur

in foodstuffs may in most instances be taken as an index of decomposition. Hanna *et al.* (24) have shown that the stinking smut of wheat—which has an odour identical with that which emanates from the human vagina—is due to trimethylamine. In view of the demonstrated effects of trimethylamine described above upon various tissues, it seems reasonably probable that the substance secreted by menstruous women which is responsible for the effects described is either trimethylamine or else a substance the decomposition product of which is trimethylamine.

In any event, the experimental evidence cited in this paper is sufficient to show that menstruous women are capable of exerting a noxious effect upon various living things with which they may come into contact. The question we now have to consider is what possible bearing such facts can have upon the origin of the prohibitions which are almost universally associated with menstruation. The suggestion is that at some period in the history of human society it was noted that certain deleterious changes produced in living things were associated with the presence of menstruous women, and that the inference was drawn that women in their periods were responsible for these undesirable effects; consequently in order to prevent such effects from occurring a prohibition was put upon women during their menstrual periods. This observation may have been made once or independently by different groups at different times. Primitive man is an extremely good observer, so that on the score of his observational powers alone the observation of such a relationship is by no means inconceivable, and though he may subsequently come to attribute the noxious effects of the menstruous woman to the operation of supernatural or magical

factors, that would not detract one whit from his ability to perceive the existence of a significant relationship and a necessary association.

There is a danger in this kind of reasoning which we must be careful to avoid—it is the danger of intellectualization. Twentieth century science appears at last to have discovered that menstruous women excrete substances which are capable of exerting a harmful effect upon living tissues of certain kinds. Primitive man has believed that women are so capable for countless centuries. Science, as the result of experimental investigation, attributes the capacity to the operation of certain chemical and physiological factors—primitive man to the operation of supernatural or magical ones.

The only question which we have to consider is whether the menstrual prohibitions of primitive man are based upon an observed relationship not clearly understood but about which a great explanatory edifice of myths and magical beliefs have been erected, or whether the menstrual prohibitions have their origin in an irrational or supernatural conception of the nature of menstruation quite apart from any observed relationship between an apparent cause and a necessary effect.

To such a question, or questions, it is clearly impossible to return a definite answer since it is historically quite impossible to know what actually generated a group of beliefs of this kind in the various parts of the world in which we find them. The same kinds of prohibitions and practises may have had numerous independent origins in different human groups, or they may have had but few, or even a single one. We do not know, and the present beliefs of primitive peoples relating to menstruation do not afford us much assistance in this connexion. The suggestion that these prohibitions origi-

nated in the recognition of an observed relationship similar to that which scientific investigation has recently proven to hold good can neither be proven nor disproven, nor can any evaluation of probability be made in respect of it. It must remain what it is—an interesting suggestion.

In favour of this suggestion there is this to be said: In most primitive human groups of which we have any knowledge the gathering of food and the practise of elementary agricultural processes are activities which more often than not are restricted to women. Such an association provides a favourable set of conditions for an observation such as Schick (51) was able to make in connexion with the freshly cut flowers that were handled by the menstruous women in his office. It requires to be pointed out that food-gathering and agricultural peoples live under conditions which necessitate close attention to, and observation of, every aspect of these most important of economic activities. These are matters upon which their very lives depend, and about which, for the most part, their lives re-

volve; hence, it is by no means inconceivable that such an observation as that menstruous women exert a detrimental effect upon the growth of various plants was at some time in some human group or groups made, and this in turn made the basis of the menstrual prohibitions. But this is a pure speculation.

SUMMARY

The experimental evidence for the suggestion that menstruous women are capable of exerting a deleterious effect upon living tissues is surveyed with special reference to the origins of the menstrual prohibitions.

It would appear that menstruous women are capable of exerting noxious effects upon many living tissues.

The indications are that a substance, excreted through the hands during menstruation, is the agent responsible. The evidence points to an alkylamine, probably trimethylamine.

The possible physiological origin of the menstrual prohibitions is discussed, and it is shown that definite conclusions in this connexion are impossible.

LIST OF LITERATURE

1. ASCHNER, B. 1924. *Die Konstitution der Frau*. München.
2. —. 1927. Ist die Menstrualblutung ein für die Gesundheit der Frau notwendiger Vorgang oder nicht? *Zentrbl. f. Gynak.*, Bd. 51, pp. 577-595.
3. ASHLEY-MONTAGU, M. F. 1938. Trimethylamine in menstruous women. *Nature*, vol. 142, pp. 1121-1122.
4. BARTELMER, G. W. 1937. Menstruation. *Physiol. Reviews*, vol. 17, pp. 28-72.
5. BÖHMER, K. 1927. Beiträge zum Menstrualblutnachweis. *Deutsch. Zeit. f. ges. gericht. Med.*, Bd. 10, pp. 430-447.
6. BORSARELLI, F. 1933. Ricerche sperimentali sul potere tossico del latte secreto in periodo mestruale. *Rev. Clin. Pediat.*, vol. 31, pp. 189-220.
7. BRIFFAULT, R. 1927. *The Mothers*. London, vol. 2, pp. 386 sqq.
8. BURR, H. S., and MUSSELMAN, L. K. 1938. Bio-electric correlates of the menstrual cycle in women. *Am. J. Obstet. and Gynec.*, vol. 35, pp. 743-751.
9. CATTANEO, L. 1933. La choline dans l'uterus humaine. *Arch. Internat. Physiol.*, vol. 37, pp. 58-69.
10. CHRISTIANSEN, W. 1929. Das Menotoxinproblem und die mitogenetischen Strahlen. *Ber. d. Deutsch. Bot. Gesellsch.*, Bd. 47, p. 357.
11. CZAPPEK, F. 1925. *Biochemie der Pflanzen*. Berlin.
12. DOGLIOTTI, V. 1932. Ricerche sulle cause della fluidità del mestruo e sul contenuto in cefalina del sangue nel periodo mestruale. *Fed. Gynec.*, vol. 29, pp. 119-138.
13. ELLIS, H. 1902. *Studies in the Psychology of Sex*. Philadelphia, vol. 1, pp. 1 sqq.
14. ELTZ, E. 1932. Über den Nachweis von Giftstoffen in der milchlaktierender Frauen wäh-

- rend der Menstruation. *Jahrb. Kindbk.*, Bd. 136, pp. 82-115.
15. F., R. B. 1878. Menstruation and the curing of meat. *Brit. Med. J.*, vol. 1, 6 April, p. 514.
16. FLECKNER, J. H. 1934. Zur Frage der Wachstumstoffe im Menstrualblut. *Monatsschr. Gebb. u. Gynak.*, Bd. 96, pp. 118-124.
17. FRAENKEL, L. 1927. Die normale und pathologische Physiologie der Menstruation. *Beihfte z. med. Klinik.*, Heft 3, pp. 53-65.
18. FRANK, M. 1921. Menotoxine in der Frauenmilch. *Monatsschr. f. Kindbk.*, Bd. 21, pp. 474-477.
19. FRAZER, J. G. 1920. Taboo and the Perils of the Soul. *London*, Part 3, pp. 145 sqq.
20. FREEMAN, W., and LOONEY, J. M. 1934. Studies on the phytotoxic index. Menstrual toxin ("Menotoxin"). *J. Pharm. and Exper. Therap.*, vol. 52, pp. 179-183.
21. GERSON, A. 1920. Die Menstruation, ihre Entstehung und Bedeutung. *Zeit. f. Sexuensch.*, Bd. 7, pp. 18 sqq.
22. GRAVES, W. P. 1929. Gynecology. *Philadelphia*, pp. 31-35.
23. GUNN, D. L., JENKIN, P. M., and GUNN, A. L. 1937. Menstrual periodicity. *J. Obstet. and Gynaec. Brit. Emp.*, vol. 44, pp. 839-879.
24. HANNA, W. F., VICKERY, H. B., and PUCHER, G. W. 1932. The isolation of trimethylamine from spores of *Tilletia levis*, the stinking smut of wheat. *J. Biol. Chem.*, vol. 97, pp. 351-358.
25. HAVAS, L. 1938. Effects of trimethylamine in plants and animals suggestive of hormonal influence. *Nature*, vol. 142, pp. 752-753.
26. HULL, E. 1928. Folklore of the British Isles. *London*, p. 21.
27. KLAUS, K. 1925. Zur Frage des Menotoxine. *Biochem. Zeitschr.*, Bd. 163, pp. 41-50.
28. —. 1927. Beitrag zur Biochemie der Menstruation. *Biochem. Zeitschr.*, Bd. 185, pp. 3-10.
29. LABHARDT, A. 1924. Zur Frage des Menstruationsgiftes. *Zentrbl. f. Gynak.*, Bd. 48, pp. 2626-2628.
30. LÁNCZOS, A. 1930. Zur Frage des Menotoxins. *Naunyn-Schmiedeberg's Arch. f. Exper. Path. u. Pharmacol.*, Bd. 156, pp. 117-124.
31. LAURENT, L. 1897. De quelques phénomènes mécaniques produits sans contact par certaines femmes au moment de la menstruation. *Annales des Sciences Psychiques*, Paris, T. 7, pp. 265-270.
32. LEVINSON, S. A. 1922. Studies on the toxicity of human blood-plasma for guinea-pigs. *J. Immunol.*, vol. 7, pp. 497-509.
33. LEVITICUS. 570 B.C. The Old Testament (Leviticus). Chap. 15, Verses 19-33.
34. LÉVY-BRUHL, L. 1935. Primitives and the Supernatural. *London*, pp. 305 sqq.
35. MACHT, D. I. 1924. Influence of menotoxin on the coagulation of blood. *J. Pharm. and Exper. Therap.*, vol. 24, pp. 213-220.
36. —. 1936. The phytotoxic reactions of normal and pathological blood sera. *Protoplasma*, Bd. 27, pp. 1-8.
37. —, and DAVIS, M. E. 1934. Experimental studies, old and new, on menstrual toxin. *J. Comp. Psychol.*, vol. 18, pp. 113-134.
38. —, and LUBIN, D. S. 1924. A phytopharmacological study of menstrual toxin. *J. Pharm. and Exper. Therap.*, vol. 22, pp. 413-466.
39. MANDELSTAMM, A., TSCHAIKOWSKY, W., and BONDARENKO, G. 1933. Experimentelle Untersuchungen zur Frage des Menotoxins. *Arch. Gynak.*, Bd. 154, pp. 636-643.
40. MEYRAN, E., and NOTHAS, R. 1929. Zur Intoxikationstheorie der Perniziösen Anämie. *Klin. Wchnschr.*, Bd. 8, pp. 697-699.
41. MICHIN, B. W. 1902. Trimethylamin und seine Bedeutung in den weiblichen Geschlechtsorganen. *J. akusch. i. shensk. bolesnij*, No. 7, (Russian). Abstracted in *Zentrbl. f. Gynak.*, Bd. 27, 1903, pp. 1390-1391.
42. MILNE, A. 1871. Principles and Practice of Midwifery. P. 46, *London*.
43. NOVAK, E. 1928. Menstruation and its Disorders. Pp. 5, 305-313, *New York*.
44. PLINY, *The Elder*. 60 A. D. The Natural History. (Translated by J. Bostock and H. T. Riley.) *London*, 1855, Bk. 7, Chap. 13; Bk. 28, Chap. 23.
45. PLOSS, H. H., BARTELS, M., and BARTELS, P. 1935. Woman. Vol. I, pp. 598 sqq., *London*.
46. POLANO, O., and DIETEL, K. 1924. Die Einwirkung der Hautabsonderung bei der Menstruierenden auf die Hefegärung. *Munch. med. Wchnschr.*, Bd. 71, pp. 1385-1388.
47. RAHN, O. 1936. Invisible Radiation of Organisms. *Berlin*.
48. —, and BARNES, M. N. 1933. On the lethal radiation from the human body. *J. Bacteriol.*, vol. 25, pp. 28-29.
49. —, and —. 1933. Tötung von Hefen durch Strahlungen des menschlichen Körpers. *Arch. f. Mikrobiol.*, Bd. 4, pp. 583-588.
50. SÄNGER, H. 1921. Gibt es ein Menstruationsgift? *Zentrbl. f. Gynak.*, Bd. 45, pp. 819-822.
51. SCHICK, B. 1920. Das Menstruationsgift. *Wien. klin. Wchnschr.*, Bd. 33, pp. 395-397.

52. SIEBURG, E., and PATZSCHKE, W. 1923. Menstruation und Cholinstoffwechsel. *Zeit. ges. exp. Med.*, Bd. 36, pp. 324-343.
53. SILBER, W. 1920. Der Cholingehalt der Frauenmilch und sein Verhalten während der Menstruation. *Zeit. f. Kindch.*, Bd. 49, pp. 210-217.
54. SPIVAK, C. D. 1891. Menstruation: a brief summary of the theories of the ancients with special reference to the views held by the Talmudists. *Times and Register*, Philadelphia, vol. 22, pp. 128-131.
55. TUTTLE, W. W. 1925/26. Changes of irritability in women during the menstrual cycle. *J. Lab. and Clin. Med.*, vol. 11, pp. 60-62.
56. VIDONI, G. 1922. L' 'impurità' della donna appunti di psicologia etnica e di fisiopsicologia sul periodo mestruale. *Quaderni di Psichiatria*, vol. 9, pp. 201-217.
57. WESTERMARCK, E. 1922. The History of Human Marriage. Vol. III, pp. 64 sqq., London.
58. WOODWARD, H. E., and ALBERG, C. L. 1921. The detection of volatile alkylamines in the presence of ammonia and of volatile tertiary alkylamines in the presence of volatile primary and secondary alkylamines. *J. Biol. Chem.*, vol. 46, pp. 1-7.
59. WÜNSCHE, A. 1884. Der Midrash Wajikra Rabba, das ist die Haggadische Auslegung des dritten Buches Mosis. P. 125. Leipzig.





NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will frequently appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to Dr. Raymond Pearl, Editor of THE QUARTERLY REVIEW OF BIOLOGY, 1901 East Madison Street, Baltimore, Maryland, U. S. A.

BEGINNING A NEW INVERTEBRATE ZOOLOGY

Being a review of *The Invertebrates. Protozoa through Ctenophora* by Libbie Henrietta Hyman. New York and London (McGraw-Hill Book Company), 1940. Pp. xii + 726. \$7.00.

By Thomas Park, Hull Zoölogical Laboratory, The University of Chicago.

Invertebrate zoölogy is a field so vast, so pregnant with interesting problems and so poorly synthesized in a critical sense that the appearance of an initial volume of a series on this subject demands careful scrutiny. The zoölogists have been hard pressed to get coordinated, yet recent, information about the invertebrate phyla. In fact, they still find it imperative to consult such dignified but pristine stand-bys as the *Cambridge Natural History* (1895-1909); Lankester's never-completed *Treatise* (1900-1909), and Bronn's *Klassen und Ordnungen des Tierreichs* (1880-). Of later years such books as Kükenthal-Krumbach's *Handbuch der Zoologie* (1923-) and several others have been available. But the American and British biologist needs a treatment in English that will be contemporary, authoritative, well-documented and in good prose. Judging from the first volume, Dr. Hyman's *The Invertebrates* (1940) will fulfill these desiderata and thereby come to occupy a unique position on biological bookshelves. The first volume is a beginning. The author, after

presenting certain general concepts of morphology, develops and defends a schema of classification and phylogeny and then proceeds to discuss in detail, and with mature appreciation of their variability, the Protozoa, Mesozoa, Porifera, Cnidaria (Coelenterata) and Ctenophora. This book would appear of enough importance to warrant special mention in these columns.

Although Chapter II (Classification) occupies only 22 pages of the total 726, nevertheless it will be of great interest to the zoölogist. Here, Hyman reviews historically the principal classificatory systems of earlier workers and, from this background, weaves her own pattern of arrangement. Some of the features of this pattern can be seen in Figure 1 which is a copy of a phylogenetic tree sponsored by Hyman. Study of this diagram brings out a series of interesting points.

PHYLOGENETIC RELATIONSHIPS OF ANIMAL PHYLA ACCORDING TO THE VIEWS OF HYMAN

1. Hyman is concerned with three important categories of animals: the "Acellular" forms or Protozoa; the "Radiata" or Coelenterates and Ctenophores, and the "Bilateria" or bilateral animals.

2. The flagellate protozoa are considered ancestral to other protozoa, sponges and a planula-like metazoan. Presumably, the flagellates also serve as a link connecting animals with plants. This treatment of the Protozoa will indubitably find welcome support although certain zoölogists

will quarrel with the implication of the term "acellular" when used in this connection.

3. The planula is placed in an important phylogenetic position as an early metazoan prototype presumably of a gastrula-like level of differentiation. This view has found corroboration recently in the careful analyses of Snodgrass (1938, *Evolution of the Annelida, Onychophora, and Arthropoda*).

4. From the planula two major lines of evolution originate. One line moves to-

are those bilateral animals in which (a) the blastopore becomes the mouth; (b) the mesoderm originates from embryonic pole cells or masses, and (c) the cleavage is of the determinate type. The Deuterostomia are those bilateral animals in which (a) the mouth in a new formation; (b) the mesoderm originates as pouch-like evaginations of the gut wall, and (c) the cleavage is of the indeterminate type.

6. The Protostomia are broken down further on the basis of the origin and struc-

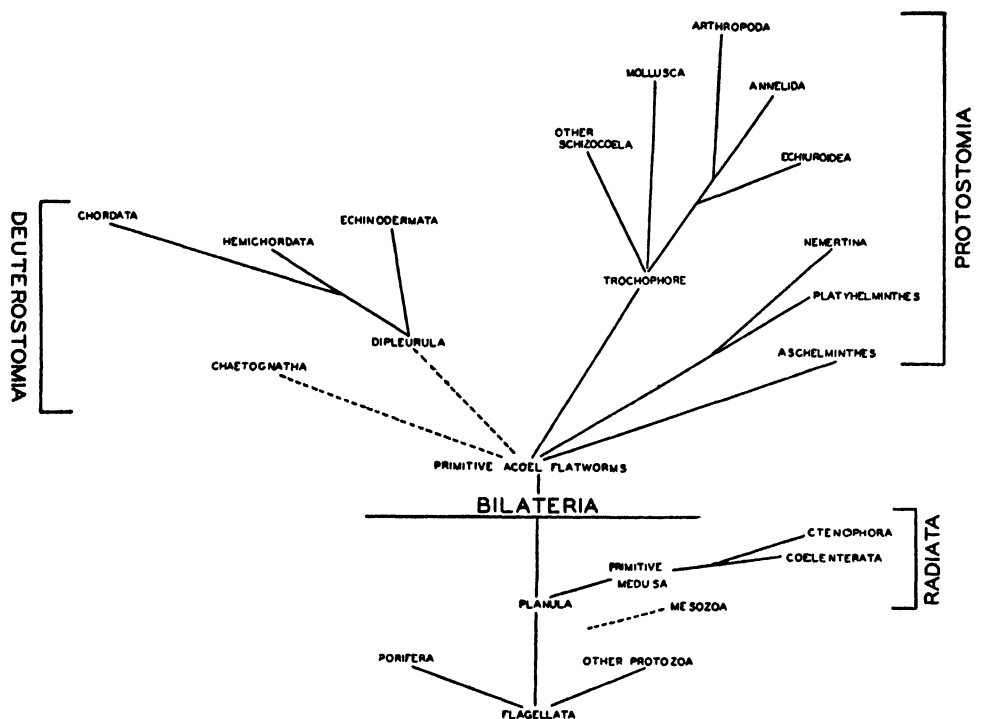


FIG. 1

wards a primitive medusa and culminates in the Radiata. The other line develops towards a bilateral metazoan that Hyman views as a primitive flatworm lacking, of course, a body cavity.

5. The bilateral animals are treated in a di-phyletic manner. The group is dichotomized into the Protostomia and the Deuterostomia. This follows the proposals of a number of earlier investigators; particularly the Germans, Goette (1902), K. C. Schneider (1902), Grobben (1908) and Hatschek (1911). The Protostomia

ture of the body cavity. Thus, Hyman recognizes those forms with no coelom (Acoelomate); those whose body cavity is a remnant of the embryonic blastocoel (Pseudocoelomate), and those which have a body cavity arising as a space (delamination) in the mesoderm (Schizocoela). The chart suggests that the flatworms and nemertean worms are partners in a common origin, namely, a primitive flatworm stock. Another line of evolution has led to a diverse pseudocoelomate group the Aschelminthes (Rotifera, Gastrotricha,

Kinorhyncha, Nematoda, Nematomorpha and Acanthocephala) and the Entoprocta. The splitting of the latter from the Ectoprocta (Bryozoa or Polyzoa) is an excellent decision. The schizocoels are truly coelomate and consist of those forms that have evolved from some type of trochophore-like larva. This assumes that the trochophores, wherever found, are fundamentally homologous stages and thus do not represent convergent or caenogenetic evolutions. As with all earlier authors, Hyman has difficulty in evaluating the Brachiopods. She finally places them with the trochophore-protostomia. This is merely a concession since, as she recognizes, they have a coelom that arises as an outpocketing of the archenteron (enterocoelous).

7. The Deuterostomia probably also originated from primitive flatworms although the evidence for this view lacks cogency. On the basis primarily of echinoderm embryology and the morphologic similarities (homologies?) between echinoderm and Tornaria larvae, Hyman conceives of the hypothetical "Dipleurula" larva as a bilateral, enterocoelous prototype of the Echinodermata and Hemichordata. Again, this is not a radical departure from a great deal of current opinion.

8. In sum, it would appear that Hyman's phyletic treatment is about as good a historical document as can be assembled at the moment. It fits a series of correlated facts fairly well and has the virtue of relative simplicity. Patently, any such device is replete with many scientific pitfalls. This is a point recognized by all careful zoologists. In fact, from a methodological aspect such efforts even may not fall into the category of science. Despite all this, most zoologists find a certain amount of phylogenetic speculation entertaining and useful mental faldral. Snodgrass puts it neatly when he says, "... Every biologist must have a working creed of phylogeny, but he should not too implicitly believe its tenets."

In this review a disproportionate amount of time has been put purposely on phylogeny. Hyman passes through this discussion with economy and dispatch. The pragmatic value of the book lies in its excellent treatment of the Protozoa, Mesozoa, Porifera, Coelenterata and

Ctenophora. Happily, the type method of presentation has been eschewed. Thus the reader learns that there is more to the protozoa than *Amoeba* and *Paramecium* and to the Coelenterata than *Hydra* and *Obelia*.

In the actual presentation each phylum is given a chapter consisting of the following material: Characters of the phylum; Classification of the phylum; General morphology and physiology; a detailed treatment of each class; General and phylogenetic considerations, and a superlative bibliography arranged primarily according to major systematic categories. Under phylum characters Hyman first reviews certain highlights that stand out in the historical development of knowledge about the group. This is followed by a definition of the phylum as a natural biological population. The section on classification deals with taxonomic categories of the rank of sub-order or above. This treatment is more than a mere roster of names since diagnostic features are given for each name presented. This can be illustrated by an example chosen at random among the Anthozoa:

Order 5. Gorgonacea, the horny corals, gorgonians, sea fans, sea feathers, etc. With an axial skeleton of calcareous specules, or of gorgonin, or of both; polyps short, equivalent, rarely dimorphic, borne on the sides of the skeletal axis, not reaching the base. (p. 371)

Throughout the book Hyman has treated all questions of terminology rigorously. If the preface she says,

... I have made an earnest effort to bring order and clarity into the confusion of zoological terminology; to define each term precisely and to adhere to that definition; and to eliminate homonyms. ... I have not hesitated to drop established terms when they appeared to me inept or confusing and have boldly coined new terms when these seemed to be badly needed.

In the general morphology and physiology sections a clear picture is developed of the biological constitution of each phylum. Within the limitations of present knowledge, the reader gets a good insight into just what constitutes a protozoan or a cnidarian and how such forms carry on many basic operations. There is also some information about special problems such as encystment, regeneration and genetics

for the Protozoa; regeneration and the problem of individuality for the sponges; nematocyst activity and metagenesis for the Coelenterata, and so on. The same mode of attack, on a more detailed plane, is followed in the discussion of each class. The phylogenetic material is a useful summary of intra-phylum relationships.

From the technical aspect the book is well prepared on the whole. The type is readable and the binding is good. There are 221 carefully selected figures that illustrate points made in the text. The book has a good subject index but lacks an author index. It is unfortunate indeed that the latter was omitted for it would have been highly useful to the reader and student. As in any undertaking of this magnitude certain errors and omissions

have crept in. But they are trifling and it would be pedantic to enumerate them here.

A first-rate reference text gives the discriminating reader the feeling that the author (1) knows, and has made good use of, *original* literature sources; (2) is thoroughly familiar with much of the *actual material*, and (3) has thought about the subject matter with trenchant perspective. It is a pleasure to report that books of this calibre on various phases of invertebrate zoölogy are increasing. The past few years have produced such scholarly efforts as *Principles of Insect Morphology* (Snodgrass; 1935) and *Principles of Insect Physiology* (Wigglesworth; 1939). Hyman's, *The Invertebrates* (first volume) takes its place along with these. Zoölogists will await impatiently Book II of the projected series.

BRIEF NOTICES

EVOLUTION

THOUGHTS ON EVOLUTION. III. *Evolution and the Primitive*. *Anthropological Series of the Boston College Graduate School*, Vol. IV, No. 3.

By Joseph J. Williams, S.J. Boston College Press, Chestnut Hill, Mass. \$1.00. 9½ x 6½; 64; 1939 (paper).

In this study the author considers evolutionary theories which have been proposed on the origin of man and the origin of monotheistic religion as related to the dim past of *Homo sapiens*. He sets forth the theories of well-known scientists and calls attention to the many contradictory reasonings contained therein. The author's object is to

determine whether a careful analysis of the facts collected show that there has been within historic times an evolutionary influence or a decadent one, directing the affairs, religious and otherwise, of the so-called Primitives of Africa, and in consequence to establish whether the theories built up by Evolutionists on their present culture are founded on objective evidence or solely on subjective preconceptions.

A second article is a pictorial and word description of the flint artifacts of the L'Abri Bergy site, of which a general description was given in the April issue of the *Anthropological Series*.

LEAVES AND STEMS FROM FOSSIL FORESTS. *A Handbook of the Paleobotanical Collections in the Illinois State Museum*. *Popular Science Series Vol. I*.

By Raymond E. Janssen. *Illinois State Museum, Springfield, Ill.* \$1.25. 9½ x 6½; 190; 1939 (paper).

This beautifully illustrated report is based mainly on the fine Langford collections of fossils taken from the Mazon Creek coal region of Illinois—although these same forms are to be found elsewhere in the state. Something over 150 genera and species are described and illustrated (164 figures, mostly photographic reproductions). The 16 different coal seams to be found in Illinois indicate that for 16 consecutive times the water rose and destroyed and buried the luxurious tropical vegetation which covered this region. The preservation of the remains is such that, in the shale beds immediately above or below the coal seams, complete leaves with their intricate veins, surface hairs and texture, and individual plant cells can be studied. A bibliography and index complete the report.

GENETICS

THE GENETIC BASIS FOR DEMOCRACY. A Panel Discussion on Race and Race Prejudice. Held at the Little Theatre, Hall of Science and Education, New York World's Fair, October 14, 1939.

By Henry A. Wallace, Franz Boas, Hadley Cantril and William A. Hamm. *American Committee for Democracy and Intellectual Freedom*, 519 West 121 St., New York. 40 cents. 11 x 8½; 25; 1939 (paper).

The average person who dislikes foreigners or racial groups other than his own is likely to think that he does so because they are inferior in some way. But the fact is that more often than not such a person has got the cart before the horse. The fact that he dislikes them is the cause for his thinking them to be inferior. It is a simple matter for the geneticist to show that there is little or no scientific basis for theories of racial inferiority, but that is not enough. The old poem about Dr. Fell carries more weight with the "morally illiterate" (this apt phrase is quoted from Mr. Hamm's contribution to this panel discussion) than all the conclusions of the scientists.

Of the four contributions to this symposium, three are exclusively diagnostic. Only one, that of Cantril, is prescriptive. He mentions by name several subversive organizations (the list might easily be made more comprehensive) whose methods and sources of propaganda might be investigated to advantage. He also warns of the flood of anti-alien (and therefore un-American in spirit) legislation that will undoubtedly try to force its way through Congress if that body should exercise its prerogative of declaring war, and suggests preparations to oppose it.

Twenty-three years ago there was only one organization in the United States concerned directly with the preservation of intellectual freedom. That there are so many more today is a sign of hope and a cause for thanksgiving.



PARTNER OF NATURE.

By Luther Burbank. Edited and transcribed by Wilbur Hall. D. Appleton-

Century Co., New York and London. \$3.00.

8 x 5½; xi + 315 + 23 plates; 1939.

The life of Luther Burbank, both as a man and as a naturalist, should be an inspiration to everyone who has the slightest interest in the wonders of the plant world about him. This thoroughly enjoyable volume is essentially an autobiography, though the material has been compiled and edited since Mr. Burbank's death, and it deals only with his work—but then his work was really his life. Burbank admitted quite frankly that he had no literary talents, but he has succeeded in putting down clearly, forcefully, and in a delightfully readable and interesting fashion, the results of his long and rich life of work in practical plant breeding, propagation and experimentation. The underlying theme of his great work, and the note that he stressed again and again, was patience. To this he added the single factor of repetition.

The clue to his success in producing new fruits, vegetables and flowers, and improving our old ones is explained in Burbank's ability to learn what nature has to teach, and to use that knowledge in directing and speeding up the natural processes by which plant evolution has taken place. The value of his work can probably never be estimated in terms of dollars and cents. His improvements on the potato alone have resulted in an estimated increase in value of more than a billion dollars in the past fifty years!

The volume is not intended for the professional botanist but for the practical and amateur plant breeder, the nurseryman, and the back-lot gardener. The text is richly illustrated, and carefully indexed.

PRACTICAL PLANT BREEDING. *Second Edition.*

By W. J. C. Lawrence. With a Foreword by Sir Daniel Hall. George Allen and Unwin, London; De La Mare Garden Books, New York. 5s. 6d. net. 7½ x 4½; 155; 1939.

Mr. Lawrence's experience as director of the gardens of John Innes Horticultural Institution has well qualified him for the

task of writing this book on practical plant breeding. The separate enterprises of botany, genetics, and plant propagation have been adequately discussed in separate volumes, but the three have probably never before been so well synthesized for the purpose of laying the foundation for a study of plant breeding, as has been done in this volume.

The range of material includes discussions on the structure of plants and flowers, the techniques of cross-pollination, the laws of heredity, and the general methods of improving plants. The volume is simply written, free from technical terminology and textbook procedures. The numerous drawings, diagrams, and photographs will undoubtedly enhance the value of the book as a guide in the hands of the amateur gardener or nurseryman. An index and a selected list of books on plant breeding conclude the volume.



POPULATION, RACE AND EUGENICS.

By Morris Siegel. Published by the Author, 546 Barton St., Hamilton, Ontario. \$3.00. 7½ x 5; x + 206; 1939.

Dr. Siegel divides his book into two parts—positive eugenics and restrictive eugenics. In the first he discusses population and eugenics and the probable etiology of differential fertility and makes recommendations for improving the situation. Much is said concerning racial theories in relation to eugenics and every effort made to deflate the claims of those who champion "Nordic superiority." There is a very helpful chapter on rational marriage from the eugenic point of view. In the second part of the book, the various mental aberrations of eugenic significance are discussed and restrictive measures proposed. There are bibliographies appended to each chapter and a good index is provided.



BIBLIOGRAPHY ON THE GENETICS OF DROSOPHILA.

By H. J. Muller. Oliver and Boyd, Edinburgh. 5s. 9¼ x 7¼; 132; 1939 (paper). Students of the genetics and physiology of

Drosophila will find this a highly useful publication. In addition to articles on this insect, the bibliography includes a few works which, although dealing with other forms, concern problems intimately connected with the field of genetic research. The material is presented alphabetically by authors and co-authors. Muller believed it inadvisable to provide a subject classification in view of the considerable amount of overlapping which this would necessitate. Titles in Eastern European languages have been translated into English and the original language indicated. Notes also appear which indicate summaries in languages other than that used in the body of the article. A number of abstracts, dissertations, and unpublished manuscripts are listed among the almost 3000 titles presented.



GENERAL BIOLOGY

ANNUAL REPORT OF THE BOARD OF REGENTS OF THE SMITHSONIAN INSTITUTION: *Showing the Operations, Expenditures, and Condition of the Institution for the Year Ended June 30, 1938.* Publication 3491.

Smithsonian Institution. U. S. Government Printing Office, Washington. \$1.50.

9 x 5¼; xiii + 608 + 11 plates; 1939. To the summary of the year's activities of the various branches of the Institution there is added, as usual, a general appendix containing papers (32 in the present volume) on a wide variety of subjects, but all of interest to the general reader. The writers, in each case, are dealing with their own special subjects in which they are authorities, hence write clearly and accurately. It is only possible, in so limited a space, to give briefly some of the topics presented: P. G. H. Boswell writes of The floor of the ocean; H. T. Stetson, The sun and the atmosphere; H. E. Wimperis, The natural limits to human flight; etc. Coming to the purely biological papers—in *Eyes that shine at night*, by E. P. Walker, we read that the cat is not alone in the shining of its eyes by reflected light. There are toads, of the genus *Bufo*, and the caiman (tropical American alligator) "whose eyes give perhaps the most

pronounced and beautiful glow I have ever observed." The eyes of most domesticated and some wild animals deteriorate in their reflecting ability in captivity. In some animals the color of the "shine" is constant, in others it may appear as three different colors within a few seconds. The paper on The black widow spider (reprinted from *The Quarterly Review of Biology*, vol. 11, No. 2, June 1936), by D'Amour, Becker and Van Riper, gives a great deal of information about this timid but much-feared insect. K. von Frisch, in writing on The language of bees, tells of training bees to color and to scent. Training to taste is impossible, "Either they [the bees] drink the solution or they refuse it." But the bees "have something like a language" and von Frisch reports some of the results of his many experiments along this line. We regret that there is not space to include some of the interesting facts brought out in such discussions as Forest genetics, The story of the maiden-hair tree, "Root-pressure"—an unappreciated force in sap movement, the Folsom problem in American archeology, and others. Illustrations, maps and bibliographies frequently accompany the texts.



KOONWARRA. *A Naturalist's Adventures in Australia.*

By Charles Barrett. Oxford University Press, New York and London. \$3.00.

8½ x 5½; xii + 315 + 49 plates; 1939.

The author of Koonwarra is a naturalist and traveler by choice, a newspaperman by profession. The name Koonwarra, meaning black swan, was chosen for the title of this book describing life on the smallest of all continents, because it has both historical and scientific significance. In 1697 William de Vlaming, a Dutch navigator, caused a furore in Europe by returning from the west coast of Australia with four swans which amazingly enough had plumage of black.

The author is most adept at spinning a yarn, and this book, which one could really call an autobiography, is full of amusing anecdotes. Not to mention beach-combers, blackfellows, bushmen, and sundry traveling acquaintances, Mr.

Barrett's family, friends, fellow scientists, and even two old maid neighbors play their rôles in this entertaining book. The author has covered a great deal of Australian territory in his search for interesting plants, animals, birds, and insects. He describes his many journeys and what he has seen on his wanderings in Queensland, central, southern, northern, and north-western Australia, through the Bass Strait and its many islands, through the Gulf of Carpentaria and its islands, on Erye's Peninsula, in Tasmania, on the islands of the Great Barrier Reef, up and down inland rivers and lakes too numerous to mention. The reader is told of the habits, habitats, and geographical distribution of such varied creatures as the giant earthworm, spiny anteater, platypus, koala, bull-ant, coccus, crocodile, wombat, tree kangaroo, cassowary, tiger-snake, python, blue-tongued lizard, lyre-bird, mutton-bird, opossum, giant clam, and the hideous deadly stonefish. There is little which escapes the observation of this witty naturalist-newspaperman. Numerous full-page photographs and a very detailed index complete the book. The reader will regret the omission of a map showing the territory covered.



THE COLLECTED LETTERS OF ANTONI VAN LEEUWENHOEK. Part I.

Edited, illustrated and annotated by a Committee of Dutch Scientists. Swets and Zeitlinger, Amsterdam. 19 guilders (paper); 21.50 guilders (bound). 11½ x 8½; 454 + 39 plates; 1939.

This fine commemorative volume, the first of a series that will ultimately comprise 20 when completed, bears witness to the esteem in which one of the earliest biologists is held by his successors and countrymen. The leading scientific institution of the Netherlands, The Royal Dutch Academy of Sciences, jointly with the foremost society of scientific physicians have undertaken to publish in this series a complete critical edition of all of van Leeuwenhoek's letters that are obtainable. A second aim is to make the works and opinions of Leeuwenhoek in-

telligible to the modern reader. The editors perhaps put it best when they say, "Whoever reads a paper by Leeuwenhoek, even when it deals with a subject in which he specializes, cannot have absolute certainty about what Leeuwenhoek actually saw and described. An interpretation of Leeuwenhoek's observations is a science and art in itself."

The present volume contains the earliest letters written by Leeuwenhoek (21 in number, dating from April 28, 1673 to February 22, 1676). Letters addressed to Huygens, Leibnitz, Magliabechi, and many others are reproduced and many original drawings by Leeuwenhoek are used to properly illustrate the subject matter incorporated in the letters. The right-hand pages of the book are in English; the left-hand pages are in Dutch. The numerous explanatory footnotes accompanying the letters testify to the thoroughness with which the committee is going about its task.

The tables of weights and measures used by Leeuwenhoek (he was the first to measure microscopic objects and hence had to select objects which could serve as standards of comparison) and placed at the end of this volume is both of historical and practical value. The biographical register of persons mentioned by Leeuwenhoek in his letters is also of great interest. The volume contains an index of names and subjects, also an index of illustrations. The completed series will form a truly monumental work of great historical value.



A NATURALIST ON RONA. *Essays of a Biologist in Isolation.*

By F. Fraser Darling. Oxford University Press, New York; The Clarendon Press, Oxford. \$2.50. 8½ x 5½; x + 137 + 28 plates + 1 folding map; 1939.

This book definitely adds to Fraser Darling's already solidly grounded reputation as a naturalist and a writer of distinction. North Rona is a tiny island off the north-west coast of Scotland. For human beings it is no gentle environment. But the Darlings (♂ and ♀), from experience

and innate liking, know how to get the most out of life in such places.

For us in our years of primitive life on three such tiny islands there has never been a dull day, though many an uncomfortable one. Our content has rested on maintaining a spirit of acceptance and having always more than enough to do—apart from goodwill within the family. I mean by a spirit of acceptance a tolerance of environmental conditions, whatever they may be, and a realization that it is no good trying to live by a routine. You must work when the work is there, and if on the next day a gale of wind and rain makes work impossible, let it be and turn your hand or mind to something else. This is the second point of having more than enough to do; I do not think anybody can be happy in the necessary restriction of island life unless there is an alternative and constructive outlet for one's energies. There has been for me on North Rona the writing of this book of essays of forest and island, in slack hours of high summer, on the impossible days of weather about the autumn equinox, and during long winter evenings when nothing could be done outside.

The content of the eight essays in this volume is reasonably well indicated by their titles: The vivid frontier; The display of birds; North Rona; The social life of animals; Ron Mor: the great seal; Sanctuaries for wild life; The mystery of antlers; Forest and island.

Altogether this is a book that every naturalist, ecologist, and animal behaviorist will want to read, for it contains much that is original and sound.



THE GREAT NATURALISTS EXPLORE SOUTH AMERICA.

By Paul R. Cutright. The Macmillan Co., New York. \$3.50. 9½ x 6½; xii + 340 + 31 plates; 1940.

Perhaps there remains more unexplored territory in South America than in any other part of the world. There are of course larger areas of barren deserts of sand, snow, and mountain never visited by man; but the unknown recesses of South America are filled with plants and animals that are still new to science or imperfectly known. For the little knowledge that we do have we owe a great deal to those intrepid naturalists and missionaries who braved the rigors of the Amazonian jungle, Argentine pampas, and the mountainous Andes.

The author of this book presents the

important discoveries and observations made by the South American naturalists from the time of Alexander von Humboldt to such contemporary men of science as Murphy, Cherrie, Tate, Ditmars, and others. The reports of various observers on a particular animal are brought together, enabling the reader to get the true picture of the animal's peculiarities. Bats, sloths, monkeys, birds, snakes, crocodiles and the fierce piranhas are just some of the animals ably and interestingly reviewed in this way. Nor are the insects, the joy and bane of all South American explorers omitted. Good illustrations, a bibliography and an index, and especially an outline map of the continent on which to trace the routes of the great naturalists, complete this fine review of South American exploration.



A FORGOTTEN RIVER. *A Book of Peruvian Travel and Botanical Notes.*

By Christopher Sandeman. Oxford University Press, London, New York and Toronto.

\$5.00. 8½ x 5½; xii + 299 + 15 plates + 2 maps; 1939.

Here is a book that will make any field naturalist green with envy. It is a diary covering three months of travel in a part of Peru that had not been explored by a scientist since 1850. The author, a well-known botanist, had dreamed of making such an expedition for years.

The greater part of Peru lies east of the Andes, and consists of three parallel valleys draining into the Amazon. It is difficult to get from one valley to another without going outside the Peruvian boundary, but no one knows exactly where these boundaries are. Two of the valleys, those of the Marañon and the Ucayali, are well known, but that of the Huallaga is practically virgin territory for the field biologist.

The author and a friend crossed the Andes near Cerro de Pasco, whither they had gone on muleback from Lima, then made their way to the source of the river at an altitude of 14,000 feet, constructed a raft on which they descended to 597 feet near Yurimaguas, and then recrossed the Andes to Trujillo on the coast. The

story of their adventures stirs the imagination and although they collected only plants their observations on animal life make the book of interest also to the zoologist, and excite his jealousy.

The book is thoroughly indexed and documented.



THE TECHNIQUE OF THEORY CONSTRUCTION. *International Encyclopedia of Unified Science, Volume II, Number 5.*

By J. H. Woodger. University of Chicago Press, Chicago. \$1.00. 9½ x 6½; vii + 81; 1939 (paper).

A detailed and elementary account of the application of the method of modern symbolic logic to the construction of theories in general, with particular reference to biological theories. The development of the technique is so clear and simplified that this brochure may well serve as the starting point for anyone wishing to learn the elementary operations in this field.

There appears to be a minor slip on p. 13, where the following passage occurs:

"Thus, of the following four examples of substitution in 'p implies q', the first three are true statements and the fourth alone is false:

- (1) $(2 + 2 = 4)$ implies (Rome is in Italy)
- (2) $(2 + 2 = 5)$ implies (Rome is in Italy)
- (3) $(2 + 2 = 5)$ implies (Rome is in France)
- (4) $(2 + 2 = 4)$ implies (Rome is in France)"

Surely if (1) and (3) are "true statements", as in the author's sense they obviously are, then by the same token (2) cannot be a "true statement" because $2 + 2$ does not equal 5, but Rome is in fact in Italy.



VERÖFFENTLICHUNGEN DES DEUTSCH-DOMINIKANISCHEN TROPENFORSCHUNGSINSTITUTS. *Hamburg—Ciudad Trujillo D.S.D. Band I.*

Edited by Adolf Meyer-Abich. Gustav Fischer, Jena. 10 x 6½; 143 + 20 plates; 1939 (paper).

This is the inaugural number of collected publications from the German-Dominican Institute for Tropical Research which was organized in the summer of 1937. The

first paper, by Adolf Meyer-Abich, contains a history of the Institute, a description of the buildings, the aims and scope of work. The other articles include: a description of *Cichlasoma vombergi*, nov. spec., by W. Ladiges; amphibians and reptiles from Santo Domingo, described by R. Mertens; anatomical reactions of the digestive tract of the parrot, *Amazona ventralis*, by M. Grasmann; two articles on microscopic fungi of the Dominican Republic, by R. Harder and G. Sörgel; geology of the Cordillera Central of Santo Domingo, by R. Weyl; and the spread of malaria in the province of Barahona, by F. Marschall.



TRANSACTIONS OF THE SAN DIEGO SOCIETY OF NATURAL HISTORY. Vol. 9, Nos. 14a and 15. *A New Subspecies of the Western Worm Snake*, by Laurence M. Klauber; *Two New Pocket Gophers from the Desert Slope of Eastern San Diego County, California*, by Laurence M. Huey.

Society of Natural History, San Diego, Calif. 10½ x 6½; No. 14a, 2; No. 15, 4 + 2 plates; 1939 (paper).



HUMAN BIOLOGY

BLACK FOLK, THEN AND NOW. *An Essay in the History and Sociology of the Negro Race.*

By W. E. Burghardt Du Bois. Henry Holt and Co., New York. \$3.50. 9½ x 6½; ix + 401; 1939.

Here is a straightforward attempt by an educated colored man to tell the story of his race. To those who ask why such a story should be told, the answer is "Because it has never been told before." We all know that the Negro was imported to America and other so-called civilized regions to supply the demand for slave labor, and we know something of the vicissitudes through which the race has passed, particularly in our own southern states. But the innocent reader whose knowledge of African history is confined to Diaz and Vasco de Gower and Livingstone and du Chaillu and the Martin

Johnsons is due for a shock when he learns that for nearly a thousand years before any of these worthies the dark continent had been permeated by Islam, and that from Islamic sources can be read the authentic accounts of nations and dynasties that rose and fell, of war and famine and the migration of peoples essentially similar to the kind of events that have occurred in every other continent.

While Du Bois is not averse to the term "Negro" he prefers to call his people "Black Folk". Although "Negro" is merely the Spanish word for black, it is a term that has been used in many diverse senses by ethnologists, and he believes that less confusion will result from the use of the English transliteration. He interprets his race in the broad sense, including all the dark-skinned, kinky-haired people such as the Dravidians and Berbers, without regard to dolicocephaly or physiognomy. To do otherwise would be to restrict the Negro to a group so small that it could not reasonably be designated a race.

Du Bois believes that the human species originated in Africa and was dark skinned. Every dark skin today is the persistence of a primitive trait. One difficulty with this theory is that the broad nose and everted lips commonly associated with the Negro race can hardly be considered primitive, as they do not occur in any pithecooid stock, which seem to have more features in common with Caucasoid physiognomy. If primitive *Homo* was black, he must have been more like the black of the Indo-Pacific region than those of Africa.

It is now commonly believed that the ancient Egyptians had black skins. References to this fact in classical literature are too numerous not to be convincing. Du Bois believes them to have been mulattoes between barbarian Semites from Arabia and civilized Ethiopians from the head waters of the Nile, and he derives a rather convincing argument from Ethiopian history which goes back nearly as far as that of Egypt.

There are some errors in the book. For instance, the author tells us that after Estebanico was killed by the Indians it was over forty years before another effort was made to penetrate New Mexico.

As a matter of fact it was less than two years after the arrival at Compostela of Cabeza de Vaca, Estebanico's white companion, that Coronado, Alvarado, El Tovar, and de Nizo had penetrated not only New Mexico but Arizona, Colorado, Oklahoma, and Kansas. Also Du Bois has misquoted Wendell Phillips' eulogy of Toussaint l'Ouverture by omitting the reference to John Brown.

The author makes an excellent point, after noting that more than fifty million Black Folk were sold into slavery in less than three centuries, by enquiring what would have been the state of white civilization today if an equivalent proportion of able-bodied whites had been impressed into slavery in Africa. But in the natural resentment which he feels against those who perpetrated the infamous traffic in human beings he overlooks the fact that the first dealer in slaves in America was a Negro apprentice who learned from his own bitter experience what pecuniary profit might accrue from the sale of his less fortunate brethren to the avaricious whites.

A better index and a few more maps would have increased the value of this excellent book.



AGRICULTURE IN MODERN LIFE.

By O. E. Baker, Ralph Borsodi, and M. L. Wilson. *Harper and Brothers, New York and London.* \$3.50. 9½ x 5½; vii + 303; 1939.

In this volume Ralph Borsodi, founder of the Sufferin School of Living, O. E. Baker, the distinguished agricultural economist, and M. L. Wilson, Under Secretary of Agriculture, incisively present the case for more self-sufficient living. The book originated in a 1938 conference at Northwestern University on "Distributive Society and the Possibilities of Decentralization."

These authors agree that agriculture is more than "soil mining"; it is a "way of life". Baker, by elaborate economic statistics; Borsodi, by broad social reasoning; and Wilson, by reference to sociological ideas and facts; present a rural culture where bare sustenance levels are often

scarcely maintained, and this where 20 per cent of our people live, where 35 per cent of our capital is invested, and where 50 per cent of our citizens are born. The intimate relationship between this rural problem and the urban problem of unemployment and relief is clearly shown.

The authors, agreeing that most of the profits of specialized farming are consumed in higher distribution costs, advocate more self-sufficient farming, not on the Robinson Crusoe level, but by using all the facilities of a scientific and industrial age to assist in achieving a better way of living.

The final section of the book, a dialogue among the authors, shows their fundamental agreement on the principles involved, but emphasizes that all specific efforts to apply these principles are still in the experimental stage. Altogether this is a significant contribution.



CRITIQUES OF RESEARCH IN THE SOCIAL SCIENCES: I. *An Appraisal of Thomas and Znaniecki's The Polish Peasant in Europe and America.* Bulletin 44.

By Herbert Blumer. *Statements by William I. Thomas and Florian Znaniecki, a panel discussion, and summary and analysis by Read Bain. Social Science Research Council, 230 Park Ave., New York.* \$1.00. 9 x 6; xvii + 210; 1939 (paper).

The Social Science Research Council has set out to appraise the outstanding studies which have influenced sociology during the last two decades or more. The purpose apparently is to determine whether such studies might lead to "the development of a self-contained and self-recruiting cult perpetuating inquiries and reports of no substantial social value, either in promise for the future or relevance for the present." A number of books have been chosen to be evaluated and among them the review of *The Polish Peasant in Europe and America*, by Thomas and Znaniecki, is the first to be completed and thus represents the first of the series to be published. This report contains Professor Blumer's review, statements by the authors of the book and also, what seems to be, a stenographic account of the panel

discussion by members of the Social Science Research Council. Blumer's review of *The Polish Peasant* is painstaking and thorough and his main criticism is levelled at the fallacies that might result from the authors' interpretations of the letters which formed the basic material of the book. The authors, in turn, justify their methodology and further explain their viewpoint which emphasizes the subjective individual element in social relations. The panel discussion, as is usual, makes for amusing reading. For reasons not easily understood, Blumer rather than *The Polish Peasant* was subjected to a verbal assault which was of the "define your terms and what is truth" kind. In addition, almost every member present took the occasion to air his views about matters not directly concerned with the subject under discussion. It is to be hoped that the other publications of the series, especially if they contain reviews as well written as this by Blumer, will not also be used as a vehicle for outbursts of professorial pronouncements.



TANGIER ISLAND. *A Study of an Isolated Group.*

By S. Warren Hall, III. University of Pennsylvania Press, Philadelphia; Oxford University Press, London. \$1.50. 9 x 6; x + 122 + 2 plates; 1939.

This is an interesting sociological study of an isolated community on an island in Chesapeake Bay. Although politically Tangier is part of Virginia, it is geographically and culturally a part of the peninsula between Chesapeake and Delaware Bays. The speech of its inhabitants is entirely free of the characteristic inflection so wide-spread south of the Potomac, partly because their ancestors settled here in the early days before the southerners had acquired their distinctive intonation, and partly because so many of them came from New England.

During the two wars that have decimated Virginia soil no army ever invaded the Delmarva peninsula—in fact, it is doubtful whether any resident of Tangier ever undertook military service. Slavery was never introduced. The culture of the

past has been preserved into the present only slightly altered by the passage of time.

The leading spirit among these early settlers was a rugged and vigorous pioneer named Joshua Thomas, around whose memory tradition has so accumulated that he has become a semi-mythical patriarch whose dead hand to a large extent still moulds Tangier culture today. And a good culture it is, in some ways in advance of that on the mainland. It reaches its culmination in a system of socialized medicine, by which each family pays the resident physician a monthly salary receiving in return the medical service it requires without further expenditure.

More recently time and the tides of the Chesapeake have taken their toll of that part of the island formerly available for residential and agricultural purposes with the natural result that the dwindling population is becoming more and more dependent on the mainland. Its distinctive culture is being forced unwillingly into conformity and will eventually disappear. The present investigation is timely and was made none too soon.



ARCHAEOLOGY AND SOCIETY.

By Grahame Clark. Methuen and Co., London. 7s. 6d. net. 7½ x 5½; xv + 220 + 24 plates; 1939.

This book, which is primarily concerned with prehistoric rather than historic archaeology, is designed for the use of the general reader. Although the author has attempted to write in a simple style using as little as possible of the superabundant terminology already encumbering the young science of prehistoric archaeology, nevertheless the general reader who tackles this book will be confronted with a sizable amount of esoteric nomenclature. The definition of prehistoric archaeology and the history of its study are discussed. Then the following subjects are considered in order: (1) how ancient sites are found and the factors instrumental in their discovery; (2) what factors regulate the preservation of early remains; (3) the modes of excavation, and the difficulties incurred therein; (4) the relative and

absolute dating of findings; and (5) the interpretation of the findings in terms of the people of the past and their societies with the interrelations of such aspects as food supply, living area, form of settlements and houses, material culture, art and religion, density of population, and social organization and behavior. Numerous concrete examples of archaeological work are presented and findings described that range over a great portion of the globe. Lastly, the author discusses archaeology and its present use in spreading propaganda, especially in such countries as Italy, Germany, and Russia. He also considers briefly the falsity of the "superior" people conception in the light of the study of prehistoric archaeology. There are many interesting sketches and diagrams and splendid full-page photographs.



THOREAU: REPORTER OF THE UNIVERSE. *A Selection of His Writings about Nature, for all Readers from Eight Years Old to Eighty.*

Selected and Arranged by Bertha Stevens. The John Day Co., New York. \$2.50. 8 x 5½; xiv + 229 + 8 plates + 1 folding map; 1939.

It is only a few of us who can have the privilege of meeting nature on such intimate terms as Thoreau. The cumber and entanglements of modern civilization are too much with us. But when we take up such a book as this and read of the sounds, colors, and smells of forest and field, and their seasonal fluctuation, or of the stories recorded in the animal tracks in the snow, of the snow crystals that sting his face, or the spears of the much maligned skunk cabbage that herald the coming of spring by perforating the snow banks that remain in sheltered places, or the voice of the stream liberated from its icy prison, or later, the voice of the toad recently waking from its hibernation as it trills its joy at the renaissance of life, or the solemn crash of a patriarch of the forest as it falls to its death, we can ask ourselves; Why have we allowed ourselves to become slaves to our environ-

ment when we might have been its masters?

The woodpeckers still percuss the hollow trunks, the sap still drops from the red maple, and the beach grass still traces circles in the sand, but there is no Thoreau to observe and record these things. Our minds are too occupied in making present wars and preparing for future ones. But at least we can find time to read Thoreau. The fourteen volumes of his collected works are here condensed into one, the material arranged topically. The only adequate expression of the value of such a book that a reviewer can make is to advise all his readers to get it and share it with him.



INDIANS OF THE AMERICAS. *Historical Pageant.*

By Edwin R. Embree. Houghton Mifflin Co., Boston. \$2.75. 8½ x 5¼; xi + 260; 1939.

An American history "written not around the colonists and immigrants but around the native Americans." The probable course of the Indian peoples as they entered this continent by way of Bering Straits and spread fan-like throughout the Western Hemisphere, in successive waves of migrations during pre-historic times, is pictured. These people, of a single stock — Mongoloid — lived together in groups for hundreds or thousands of years, "cut off almost completely from people of other customs. Each group built its life on the basis of the habits it had brought with it and on the environment of its new home." This lack of contact with other types of culture and of ideas kept the Indian civilization more or less stabilized at a low level. It was only in those regions where contact among the various tribes was greatest that cultural development reached its highest level, namely among the Aztecs in Mexico, the Mayas in Central America and the Incas in Peru. Separate sections are devoted to these three groups—their art, learning, religion and history.

The latter half of the book is concerned with the different tribes of the North American Indian; and the final pages,

with the new governmental policy for the present day Indian. The volume contains many interesting illustrations and is well documented and indexed.



THE CHINESE ARE LIKE THAT.

By Carl Crow. Harper and Brothers, New York and London. \$3.00. 8½ x 5½; viii + 328; 1939.

It is apparent from this book that in the twenty odd years the author spent as an advertising man in China, he has gained a shrewd insight into Chinese character and custom, a genuine fondness for these people, and a high regard for the many ways in which they have met the struggle for survival and live uncomplainingly in the midst of flood and famine, poverty, scarcity of firewood and pure water, and over-population. Here he shows how rice (in the south) and noodles (in the north), which do not require a long and steady fire for cooking, came to be the staple diets of the country, not because of what "Confucius say", but because of deforestation resulting in scarcity of firewood and game. He shows the extent of the famine that would result if modern plumbing were installed in every home to replace the present custom, found nauseating by foreigners visiting the country, of collecting human manure for disposal over the fields. He traces the origin of another custom found annoying to foreigners, namely that of "squeeze", which incidentally seems to be a trait of servants all over the world. He writes of beggars, bandits, noise, superstitions and many other things. Most of the attitudes of mind and customs which non-Chinese find peculiar, Crow finds can be logically traced back to some basic reason. Written in a popular style and illustrated with amusing anecdotes this book is nevertheless worth the perusal of the serious minded student of human populations and customs. It has been published in England under the title *My Friends, the Chinese*.



RACIAL PROVERBS. *A Selection of the World's Proverbs Arranged Linguistically.*

With Authoritative Introductions to the Proverbs of 27 Countries and Races.

By Selwyn G. Champion. The Macmillan Co., New York. \$10.00. 9½ x 6; cxxix + 767; 1939.

Proverbs are important to the human biologist. They are the quintessential distillates from the long boiling of the great pot of human experience. When a Chinese boy's grandfather suggests to him that: "If you bow, bow low", he is imparting to him a bit of worldly wisdom based upon a vast experience of human behavior. Obeisance, toadying, boot-licking, or whatever it is called, may or may not be an advisable action in a particular situation; but if it is decided to be the sound thing to do in the premises, racial experience has demonstrated that a thorough job had best be done.

From the point of view of the student of human behavior, as well as from every other conceivable, except perhaps the narrowly philological, this huge collection of proverbs assembled on a racial (national) basis will be a boon to students. Twenty-seven distinguished scholars contribute introductions to as many sections, starting with an African section for which R. R. Marett is responsible, and an Arabic section from the pen of Prof. H. A. R. Gibb; and ending with the Turkish (S. Topalian) and the Welsh (J. J. Jones). There is a 20-page bibliography of authorities consulted; and three detailed indices.

Altogether this collection of 26,000 odd proverbs from 186 languages and dialects, that cost the editor 27 years of research, is a scholarly contribution of a high order of importance.



SOCIAL RESEARCH.

By Manuel C. Elmer. Prentice-Hall, Inc., New York. \$3.00. 8 x 5½; xvi + 522; 1939.

The purpose of this book is to outline the principles and philosophy of research in the social sciences. As the author notes, the methods of research so well established in other branches of science have not been utilized to any great extent in sociology. One of the reasons, he believes, is that "social research has fre-

quently manifested itself as a vehicle for changing the social order rather than of understanding the social order." This is only too true, although not many professional sociologists are willing to admit it. There are three research techniques that the author describes in this book: (1) the general historical method of studying events and institutions, (2) the individual life history, (3) the case method. The last mentioned is discussed in great detail with particular reference to its use in so-called surveys. For all methodological approaches, in general, the author refers at length to the problems involved in sampling, the choice of adequate control groups, the use of statistical analysis and the various scales employed in measuring individual and social group attributes and phenomena. Although to students trained in biology and biometrics the book may seem very elementary, it is worth reading for the good choice of illustrative examples and adequate bibliography.



HORSES AND AMERICANS.

By Phil Stong. *End paper and chapter heads by Kurt Wiese. Frederick A. Stokes Co., New York.* \$5.00. 10 $\frac{1}{4}$ x 7 $\frac{1}{2}$; xx + 333 + 65 plates; 1939.

Here we have a book decidedly easy to read, in which has been accumulated a most amazing quantity of information about the horse and its development in America.

No horses were native to the continent when Columbus made his voyages but they arrived here almost on the rudder of the *Santa Maria*, certainly within ten years of the navigator's death. Velasquez established the animals in Cuba, one of Columbus' first discoveries, in 1511; seven years later the island furnished mounts for the conquest of Mexico.

The author brings us into close contact with the different breeds of horses, which we are familiar with in a general way, and explains their usefulness as decided by their build—saddle and race horses, hunters, cow ponies, heavy Percherons, Clydesdales, Belgians, Morgans, and just horses, some pure bred and some crossed. Stong also makes us aware of the exceedingly important part played by the horse

during the settlement of this country, and speculates as to how much the development and extension of our territory might have been retarded without them. Many illustrations are included, a substantial bibliography, and an index.



ANTHROPOLOGY AND RELIGION.

By Peter H. Buck. *Yale University Press, New Haven; Oxford University Press, London.* \$1.50. 8 x 5 $\frac{1}{2}$; viii + 96 + 1 folding chart; 1939.

This book embodies the sixteenth series of Terry Lectures on Religion in the Light of Science and Philosophy, delivered at Yale University. Professor Buck, who was born in New Zealand of a Maori mother, traces the history of Polynesian religion, its development and solidification, and eventual destruction with the advent of Christianity. The Polynesians deified certain of their ancestors and thus created their gods, the priesthood developed and fixed the theology and, as the author says, the man-created gods in turn re-made man. The culture and whole civilization of the Polynesians became centered around their religion. Then came the Christian missionaries with a new set of morals and a new theology and by their well-known persuasive methods converted the natives. As a consequence the whole fabric of the Polynesian civilization came apart. In closing, the author points to the importance of Christianity in the development of western civilization and warns of the possible downfall of this civilization if Christianity should be abandoned. An interesting and well-written book.



THE CULTURE HISTORICAL METHOD OF ETHNOLOGY. *The Scientific Approach to the Racial Question.*

By Wilhelm Schmidt. Translated by S. A. Sieber. *Fortuny's, New York.* \$5.00. 9 x 6; xxx + 383; 1939.

The primary purpose of this tedious, dull, and badly written treatise, appears to have been to bring about a wider dissemination of the ideas and theories of

Graebner and Schmidt about what they hold to be the true methodological gospel of ethnology. Particularly there was apparently a hope that by translating Graebner's *Methoden* and spreading it about in chunks through a diluent it might be made readable. It is our duty to report that the hope was largely illusory. As the result of a prolonged, careful, and sympathetic study of this volume it is our conviction: (a) that Boas was profoundly right and wise in refusing to accept the *Kulturkreis* theory of Frobenius, Graebner, Schmidt and Co., because "it is based on the assumption of the permanence of correlations of supposedly identical cultural traits, the identity of which has not been safely established and which in modern cultures prove to be unstable"; and (b) that if the company wants to promote the sale of its eyewash it will do well to employ a bright young man who can write clearly and logically so to put the product out in a brighter, cleaner, and generally more attractive package.



OUT OF REVOLUTION. *Autobiography of Western Man.*

By Eugen Rosenstock-Huessy. William Morrow and Co., New York. \$6.00. 8½ x 5½; xii + 795; 1939.

Out of Revolution, an autobiography of western man, is a philosophy of history with "revolution" as its arbitrary unit of progress. The author attempts to show the human experiences and thoughts underlying revolutions and the interdependence of revolutions to each other. The author treats history as the autobiography of man and the revolutions that have made history and have given "man's soul a new relation between present, past and future" as having their foundations in the alternating passions of humankind.

In the first part of the book the author discusses the great revolutions of Russia, France, England, and Germany, a four-hundred-year span of history; in the second part, the clerical revolutions in Italy and the American Revolution. The author quite often sacrifices clarity of

meaning to a well-turned sentence or phrase and drowns the meaning of his analyses in a flood of unnecessary verbosity. The volume is well illustrated, and has a detailed index. An explanatory list of maps and illustrations is appended to the text.



RELIGION IN PRIMITIVE SOCIETY.

By Wilson D. Wallis. F. S. Crofts and Co., New York. \$5.00. 9 x 6; ix + 388 + 8 plates; 1939.

Wallis presents a thorough and scholarly review of the ritualistic manifestations of religion and of the concept of sacredness in various religions. In order, he describes the several kinds of sacred places, objects, trees, animals and persons. He then discusses the rituals of consecration, purification, sacrifice and feasts. The book ends with chapters on the beliefs about life after death. Although, as the title indicates, the author is concerned with the religion of pre-literate cultures he discusses equally the manifestations of Hindu, Mohammedan, Roman, Greek and Jewish (thereby also the Christian) religions. The great value of this work lies in the fact that it is devoted to a description rather than to an interpretation of the overt practices of religion. For this reason and because it contains an extensive bibliography this book will without doubt become a standard source of reference on the subject.



UNDER YOUR FEET. *The Story of the American Mound Builders.*

By Blanche Busey King. Dodd, Mead and Co., New York. \$2.50. 8½ x 5½; xii + 169 + 25 plates; 1939.

The story of the moundbuilder and his place in American pre-history has never been adequately told. Although the valleys of the Ohio and Mississippi are full of his works, many of which have been excavated, the knowledge about his culture is in a widely scattered state; it has never been coordinated, or even collated.

In this book an active archaeologist with a curiously diffuse literary style has

attempted to supply this deficiency. Although largely a recital of personal experience and crowded with reminiscences that have nothing to do with archaeology, it is a readable work that covers the ground thoroughly and gives an accurate account of the mysterious progenitors of the modern Indian. The illustrations are good, the documentation weak, and there is no index.



ANTHROPOLOGIA CRIMINAL (*Conferencias e Comunicações*).

By Leonídio Ribeiro. *Imprensa Nacional, Rio de Janeiro*. 10 $\frac{1}{4}$ x 7 $\frac{1}{2}$; xii + 97 + 27 plates; 1937 (paper).

This volume contains a collection of papers presented and read by the author at several Portuguese universities and at the 1937 Paris Congress on Legal Medicine and Industrial Hygiene. The articles concern three subjects: juvenile delinquency, homosexuality; and the effects of leprosy on fingerprints. The papers regarding the first two subjects contain mainly summary reviews of theories. The author is an adherent of the neo-Lombrosian school of criminologists and believes that delinquency as well as homosexuality represent manifestations of biological variations and consequently are medical more than police problems. Of particular interest are the observations presented relative to the changes in the fingerprints as a result of leprosy. Apparently this disease brings about the one exception to the fixity of fingerprints and creates a problem relative to police identification. In turn, the author notes, this alteration may be of value in the study of the course of the disease.



MY LIFE. *Autobiography of Havelock Ellis.* Houghton Mifflin Co., Boston. \$3.75. 8 $\frac{1}{2}$ x 5 $\frac{1}{2}$; xii + 647 + 8 plates; 1939.

Havelock Ellis, stating his belief that "of all forms of prose, there is no form so precious in its nature and so permanent in its value as an autobiography", defines the purpose of *My Life* as the "desire that my experience of life may help those who

come after me to live their own lives". The work emphasizes the "inner man" and is chiefly noteworthy for the impassioned correspondence with his wife.

The book was "an act of prolonged precision in cold blood, beyond anything else that I have written" and was completed only shortly before his death. The style is detached, calm, rambling and reminiscent, enlivened only by the correspondence.

The noble plan of showing that "this is life" achieves more of ashes and dust than of living. Of itself, the book, though beautifully written, arouses no intensity of interest. Any permanent value that the autobiography may possess lies in the fact that it serves as a documentation of the actually far more interesting life and times of its famous author.



FAMILY INCOME AND EXPENDITURES: Plains and Mountain Region. Part One, Family Income. U. S. Department of Agriculture. *Miscellaneous Publication No. 345. Consumer Purchases Study. Urban and Village Series.*

By Gertrude S. Weiss, Day Monroe and Kathryn Cronister. *Government Printing Office, Washington*. 30 cents. 9 $\frac{1}{8}$ x 5 $\frac{1}{4}$; iv + 330; 1939 (paper).

This investigation was carried on from January 1935 to December 1936, in several small cities and villages in the Plains and Mountain Regions of the west, and covers the pooled income of native-born families consisting of husband and wife, children, and others living with them. The income, both earned and unearned, is broken down and studied statistically from many angles. The numerous tables recorded should be of value to students of socio-economics. They may also be useful and enlightening in the study of population—all this provided the results indicated by the different tables can be relied upon as to the information upon which they are based. One gets the impression that some of the data used might not be reliable. This seems to apply principally to the report on income of the different groups. There does not seem

to be any method of checking statements made as to income.



THE EYAK INDIANS OF THE COPPER RIVER DELTA, ALASKA.

By *Kaj Birket-Smith and Frederica de Laguna*. University of Pennsylvania Press, Philadelphia; *Levin and Munksgaard*, Copenhagen. \$6.00. 9½ x 6; 592 + 17 plates + 1 folding chart; 1938 (paper).

This long and somewhat rambling ethnological account of the Eyak Indians is based upon material gathered by the authors during an archaeological and ethnological expedition to Prince William Sound during the summer of 1933.

In the first part of the report the authors discuss in detail the various phases of Eyak material, their social and intellectual culture. Part II, devoted to native folk lore, consists largely of a series of stories and legends which the authors have repeated as nearly as possible in the language of their native informants. Some of these are quite delightful in their simplicity. Part III is a critical analysis of the previous work on the Eyak, and Part IV attempts to analyse the various forms of Eyak culture discussed in Part I.

Appendices include a genealogical table and over 25 pages of Eyak vocabulary. Some excellent photographs, maps and a few text figures supplement the work. There is also an extensive bibliography.



PEOPLE. *The Quantity and Quality of Population.*

By *Henry Pratt Fairchild*. Henry Holt and Co., New York. \$3.00. 8½ x 5½; [6] + 315 + 8 plates; 1939.

This is a discussion of the quantitative and qualitative aspects of population with the mathematics omitted. Specialists who enjoy reading vital statistics can obtain them from other sources, but the object of this work is to stimulate interest in population problems among those who have had no special preparation for quantitative work.

The doctrine of Malthus is discussed with great clarity, and is interpreted in a somewhat different form from its popular conception. The problems attending birth control and the qualitative aspect of population, i.e., eugenics, are discussed lucidly. The index is very analytic and covers 15 pages.



RURAL MIGRATION IN THE UNITED STATES. *Works Progress Administration, Division of Research. Research Monograph XIX.*

By *C. E. Lively and Conrad Taeuber*. U. S. Government Printing Office, Washington. 9½ x 6½; xxi + 192 + 12 plates; 1939 (paper).

As a basis for the WPA programs of unemployment relief and guided migration, the movements of rural population have been studied both before and since 1930. The analysis is based on census data, and on data gathered directly from 22,000 rural families in field surveys. Widespread economic need in rural areas is made clearly evident.



ZOOLOGY

CELLULOID SAFARI. *Filming Big Game from Cape to Cairo.*

By *Stirling Gillespie*. Photographs by *J. Blake Dalrymple and the Author*. Blackie and Son, London and Glasgow. 20s. 6d. net. 8½ x 5½; x + 278 + 63 plates + 1 map; 1939.

This is the record of the experiences of two young Scotsmen who traveled from Capetown to Cairo in "Big Bertha", a Ford V8 sedan, covered more than 25,000 miles mainly along the eastern coast of Africa, and arrived in Cairo three days sooner than the 455-day allotted schedule. The purpose of the expedition was to photograph and film educational material on the native life and wild animal life of Africa for the use of British and Empire Schools. The book is written in a highly entertaining conversational style, and no one who reads it will be able to suppress laughter over the difficulties incurred by the young men in getting "Big Bertha".

to Cairo. Very interesting to photographers will be the descriptions of the stalking of big prey with cameras. "It was strange that we had come through Africa without a rifle or shot-gun. . . . But at no time were we tempted to destroy the creatures we were photographing, nor did we find it necessary to kill in self-defense, except in the case of two deadly snakes." There are many amusing anecdotes about the natives, especially about the Zulus who cast aside all things native as contemptible. These natives had donned such European clothing as moth-eaten football jerseys, tams, berets, felt hats, while some, preferring to exhibit their entire wardrobes, would wear as many as three greatcoats on the most sweltering days. This book gives an excellent picture of the population of Africa, both white and native, its wild life, and the topography of the land with emphasis laid on the traveling conditions on man-made routes and off the beaten tracks. There are numerous full-page photographs. On the front end-paper there is a map showing the route taken by the two photographers.



MY FRIENDS THE BABOONS.

By *Eugène N. Marais*. Methuen and Co., London. 5s. net. 7½ x 5½; vii + 124; 1939.

The author believes that

If mankind wishes to escape the doom which now threatens its existence on earth; if, in the last ditch, man still wishes to fight unrelenting nature, it would appear possible only by the adoption of one strategical measure and that is the variation from type and the great increase in population must be stopped in some scientific way. For this purpose science must be called in, and the first step towards acquiring the necessary knowledge to arm man for his last struggle for existence is a thorough study of the animal species most nearly related to man—the apes and anthropoid apes.

This account of the activities of a colony of baboons of South Africa is interesting, but not entirely convincing. We doubt that mankind will be saved by a study of this nature. The entire account of the behavior of these apes is tinged with the author's anthropomorphic conception of how they should behave, and as a con-

sequence one becomes skeptical. This is unfortunate, for there is much material gathered here for the first time on the social life of baboons in their wild and natural state.

In one of the chapters the author expounds the theory "that birth-pain is the key that awakens the psychological impetus of mother-love." "In the baboon mother-love reaches a higher stage of development than in any other animal in our country and the birth-pain she suffers is proportionate to it."



WILD ANIMALS. *Great Wild Animal Stories of Our Day.*

Compiled by *Frances E. Clarke*. The Macmillan Co., New York. \$2.50.

8½ x 5½; x + 335; 1939.

The charm of this collection lies not only in its beautifully written stories and essays (25 in number), but also in the well-selected diversity of its subject matter and appeal. For the reader who desires an essay on the spiritual side of nature and the conservation of its wild life and plant beauty, there is the article "Thou Shalt Not Kill", by James Oliver Curwood who died before this, his last article, could be put into type; for the reader who likes a story of nature with a dash of Tolstoi-like religious moral at the conclusion, there is "The Truce of God," by Laurence Housman. For one who likes a good animal story with action, but no sentimentality, there is the story, "The Black Coyote," by Myron M. Stearns; for one who likes an animal story with a tinge of sentimental tragedy, there is the story of the giant ape mother "The Prisoner," by Madelon Lulofs. For the reader who likes his story with a dash of comedy there is the story of Ulysses Skunk entitled "The Lord of the Trail", by Kenneth Gilbert. Muztagh, the great white Indian elephant; Alessandro, the little hurdy-gurdy monkey who returned to the jungle to dance before his jungle relatives in a green pea-jacket; Joe Dokes, the African-born circus lion who was a beloved retired veteran of the Grand Amalgamated Circus; and Koala, the little Australian marsupial

bear, are some animal-heroes, about whom not-to-be-forgotten stories have been written, that have been included in this excellent anthology.



AMERICAN MAMMALS: *Their Lives, Habits, and Economic Relations.*

By W. J. Hamilton, Jr. McGraw-Hill Book Company, New York and London.

\$3.75. 9 x 6; xii + 434; 1939.

Mammalogists, naturalists, sportsmen, and biologists will rejoice to hear that there is finally available an up-to-date book on the biology of mammals. Previous works have heretofore been limited in scope, usually being either taxonomic, distributional, or economic, with scattered notes on behavior and life history. Hamilton presents a general and broad review of the lives, habits, and economic relations of American mammals.

The book properly starts out with the ancestry and classification of the mammals, followed by chapters on their general biology which include their adaptations, food, reproduction, homes, hibernation and migration, populations, behavior, and distribution. The final chapters are devoted to the economic importance of these animals, their usefulness and destructiveness, and their value as fur and game.



THE WAY OF A LION.

By Alden G. Stevens. Drawings by George F. Mason. Frederick A. Stokes Co., New York.

\$1.75. 8½ x 5½; xvi + 144; 1939. *The Way of a Lion* represents the best in animal stories. It is a far cry from the usual sentimentalized fiction. This is not the life history of an imaginary lion, but one which the author himself has seen and about which he has heard much from the Masai warriors of East Africa. The hero, a great giant of a lion with a massive head, is not only picturesque but full of cunning. His prowess as a hunter had spread the length and breadth of the Serengetti. The author, however, does not just present the lion as a mighty monarch of the jungle. The reader is

told of the lion's birth (ca. 1920) in a cave on a hill somewhere north of Ngoro Ngoro, his awkward cubhood, his orphaned, lonely life as a cub in the bush, his youth and mating, his supremacy as a lord of the plains, encounters with men and animals, and finally, death met courageously and in the prime of life. Here is a story that is realistic, but not sentimentalized; vivid, but not sensational. The story has a rich setting—the plains and forests of East Africa with the intensely hot sun of the "blue, blue sky of Africa" blazing down upon all. There are seven full-page drawings and numerous marginal sketches. A fascinating record of animal life for adults and children from 12 on.



DESTRUCTIVE AND USEFUL INSECTS: *Their Habits and Control.* Second Edition.

By C. L. Metcalf and W. P. Flint.

McGraw-Hill Book Company, New York and London. \$7.50. 9 x 6; xvi + 981; 1939.

The great advances in the science of insects, especially in the field of economic entomology has made a complete revision of the first edition (Q. R. B., Vol. 4, p. 436) of this book necessary. The methods of insect control with insecticides of arsenic and lead have been replaced, life histories have been worked out, and the bionomics, morphology, and physiology of insects have progressed to such an extent that nearly every page of this huge text has been altered.

An interesting new feature is a key to the orders of insects in their immature stages in addition to the usual key to the adults. The first part of the book is devoted to the morphology, development, and classification of insects, followed by chapters on insect control. From this point on the insects are described according to the host plant or animal. The insect's importance, the type of injury it incurs, the plants attacked, its distribution, life history, appearance, and habits are all part of the information given for each species. Following the discussion are one or more references to more detailed works.

This excellent textbook is profusely illustrated and well indexed.



STANFORD ICHTHYOLOGICAL BULLETIN.
Volume I, Numbers 1, 2, 3, and 4.

Edited by George S. Meyers. *Natural History Museum, Stanford University, California*. In exchange for journal or serial containing material of ichthyological or fisheries interest. 10 x 6 $\frac{3}{4}$; 160; Nos. 1 and 2, 1938, Nos. 3 and 4, 1939 (paper).

This new Bulletin, which will be issued irregularly depending on the material at hand, is introduced as a vehicle for the publication of the results of ichthyological research originating in, or connected with, the Natural History Museum of Stanford University. Systematic revisions, phylogenetic studies, and correlations of scattered works in classification will be given precedence over mere lists or reports on collections.

The present numbers are concerned with the following subjects: West Indian clupeid fishes of the genus *Harengula*; Two new gobiid fishes of the genus *Gobiosoma* from Lower California; Contributions toward a revision of the ophichthyid eels. I. The genera *Callechelys* and *Bacicanichthys*, with descriptions of new species and notes on *Myrichthys*; A review of the myctophid fishes of the Pacific coast of the United States and of Lower California.



THE CARE OF A SMALL RAT COLONY.

By Rolland J. Main. C. V. Mosby Co., St. Louis. \$2.00. 8 $\frac{1}{2}$ x 5 $\frac{3}{4}$; 101; 1939.

Careful planning is as necessary for the successful colonization of rats as it is for any other group of the animal kingdom that is to be subjected to experimentation. The present treatise is a report of the "experience rather than a discussion of the entire field" in the establishment of a small rat colony at the Medical College of Virginia, and includes "that information of which we were in dire need when starting the colony." Existing publications gave some valuable infor-

mation (a list of 15 titles is given in the appendix, which also contains a list of firms where cages and equipment, and feeds can be obtained), but mostly it was by the method of "trying and rejecting various procedures" that the satisfactory methods herein described concerning equipment, hygiene, rearing, feeding, and many phases of daily routine were obtained. Included in the text are illustrations of apparatus and charts. A number of amusing rat caricatures, drawn by Dr. Margaret Pennington, are used as chapter tailpieces. An excellent index is provided.



THE BUTTERFLIES OF THE NIAGARA FRONTIER REGION and *Beginner's Guide for Collecting, Rearing and Preserving Them*. *Bulletin of the Buffalo Society of Natural Sciences*, Volume XIX, Number 1.

By William Wild. Buffalo Museum of Science Press, Buffalo, N. Y. \$1.00. 9 $\frac{3}{4}$ x 6 $\frac{1}{4}$; 55; 1939 (paper).

The list of eight families of butterflies native to the Niagara frontier region will be of interest to only a limited number of naturalists working in that region. However, the monograph contains much that will be of interest to everyone everywhere whose studies concern the Lepidoptera. The discussions on the life history of butterflies in general, the methods of collecting, rearing, and preserving butterflies and moths will appeal to the latter group.

In the matter of classification, the author has followed McDunnough's Check List of 1938.

The 12 figures, the 8 plates carrying 88 illustrations, the bibliography of 11 titles, and the complete and well-arranged index serve the volume well in its intended purpose as a field guide and reference book.



A LABORATORY GUIDE IN ENTOMOLOGY: *For Introductory Courses*.

By Robert Matheson. Comstock Publishing Co., Ithaca, N. Y. \$2.00. 11 x 7 $\frac{3}{4}$; vii + 135; 1939.

This well-planned and carefully-prepared

manual is intended for use in the laboratory work connected with an introductory course in entomology. The nature of the work is such that a fundamental knowledge of invertebrate zoology is prerequisite for undertaking it. The material is organized around the taxonomic and general biological aspects of entomology. The first nine studies are devoted to the external structure and metamorphosis of a typical insect. There follows, in studies X to XXI, a series of discussions on the characteristics used in classifying the principal families of ten orders of our common insects. Studies XXII to XXVIII deal with the behavior and economic importance of several groups of insects, particularly insect pests.

An appendix dealing with methods of collecting, preparing, mounting, preserving and rearing insects, and an informative glossary serve to round out this comprehensive and authoritative laboratory manual.



CANADIAN LAND BIRDS. *A Pocket Field Guide.*

By P. A. Taverner. Illustrated by Allan Brooks, F. C. Hennessey and P. A. Taverner. David McKay Co., Philadelphia. \$2.50. 6½ x 4½; 277; 1939.

This colorful field guide of Canadian birds will undoubtedly acquire immediate popularity among professional as well as amateur ornithologists.

The early chapters deal briefly with the following subjects: (1) methods of bird study; (2) methods of attracting birds to our gardens; (3) plans for building bird houses; and (4) the topography of the characteristic land bird. There follows a comprehensive field color key, and finally a listing of some thirty-eight families of familiar Canadian birds, together with brief notes on the size, field marks, voice, habitat, nest and eggs of each group. The scientific nomenclature follows the check list of the American Ornithologists' Union (1931) edition. The carefully drawn and beautifully colored plates greatly enhance the value of the volume as a pocket guide.

FIELDBOOK OF ILLINOIS LAND SNAILS. *Manual 2.*

By Frank C. Baker. Natural History Survey Division, Urbana, Ill. \$1.00. 7½ x 4½; xi + 166; 1939.

This is a perfect example of what a field book should be. The brief introduction contains an account of the anatomy of a land snail, instructions for collecting shells and displaying them in a cabinet, and descriptions of the physiography and geology of Illinois. The systematic portion of the book is exhaustive, covering all snails known to have been taken in the state, whether native or exotic. Of each one there is an excellent drawing. Snails whose presence is doubtful are listed without illustration, but with a bibliographic reference in an appendix.

There is a topical index of six pages and a systematic index of one, yet the book can be comfortably carried in the coat pocket. A field book of this sort will be welcomed by every field malacologist.



AN INTRODUCTION TO ANIMAL BIOLOGY.

By John B. Parker and John J. Clarke. C. V. Mosby Co., St. Louis. \$3.75. 8½ x 5½; 503; 1939.

Taking Agassiz' advice to "Study Nature, not books," the authors intend their book to be used in conjunction with a laboratory course covering essentially the same material. With a few exceptions each chapter could be used as the basis of a laboratory exercise, yet there is a sufficient amount of theoretical material included to make a well-rounded text. The authors, who are on the staff of the Catholic University of America, have been particularly careful in their handling of topics that touch on religious faith and morality—for example, the paragraphs on evolution and the statements on venereal disease. There are many illustrations.



SEPIA. *L.M.B.C. Memoirs on Typical British Marine Plants and Animals.* Edited by R. J. Daniel, XXXII.

By David H. Tompsett. University Press

of *Liverpool, Liverpool*. 12s. 6d. net.
9½ x 6; vii + 184 + 24 plates; 1939.

This is a very thorough anatomical study of one of the more plentiful species of Cephalopods in European waters. It is of course highly technical and of no special interest except to the systematist. The most striking anatomical feature of this squid is the hectocotylus, which is never detached, but is used by the male to transfer the spermatozoa from its own mantle cavity to the bursa copulatrix of the female. There is nothing in the treatise about the cleavage of the egg, or any embryological processes, and naturally, nothing about the probable evolution of Cephalopods from the primitive molluscan type, though this latter is figured and briefly described. The 24 plates are beautifully prepared.



THE TRAMPLING HERD. *The Story of the Cattle Range in America.*

By Paul I. Wellman. Illustrated by F. Miller. Carrick and Evans, New York.
\$3.00. 8½ x 5½; 433; 1939.

In 1521 an enterprising Spaniard brought 6 or 7 calves to Mexico. They thrived and multiplied, and the business of raising cattle flourished beyond the Rio Grande. The "trampling herd" gradually displaced the buffalo from the prairies to the north; and by the middle of the 19th century they grazed on open range as far as the Canadian border, and from the Mississippi to the Rockies. The brief era of the traditional "old west", of Billy-the-Kid, Wild Bill Hickok, and Wyatt Earp, of recorded "trail-drives", booming cow towns, and gun fights, marked the disappearance of the open range. Mr. Wellman's story of the transition from free land to fenced fields reveals the changing balance between a rapidly growing population and its natural resources. It is an interesting book, as readable as the author's novel of cowboy life, *Jubal Troop*.



THE GEESE FLY HIGH.

By Florence P. Jaques. Illustrated by Francis L. Jaques. University of Min-

nesota Press, Minneapolis. \$3.00. 10½ x 7½; [6] + 103; 1939.

The Rainey Wild Life Sanctuary, now owned by the Audubon Society, is the principal setting of this book. Mrs. Jaques vividly describes how she and her husband followed the ducks and geese in their southward migration, and observed them from the Louisiana marshlands. The volume contains little of biological interest, but is rather devoted to details of the charms and chafes of the rugged existence led by the vacationers. Otherwise it is a series of excellent action pictures done in black and white by Mr. Jaques, and colored in the words of his companion.



FOOD HABITS OF PRAIRIE DOGS. U. S. Department of Agriculture. Circular No. 529.

By Leon H. Kelso. Government Printing Office, Washington. 5 cents. 9½ x 6; 14; 1939 (paper).

This short bulletin presents the results of laboratory analyses of the stomachs of some 545 North American prairie dogs. About 97.47 percent of the diet of the three species examined was made up of vegetation; 78.32 percent being represented by plants important for forage or crop value, and about 19.15 percent by those unimportant for these purposes. The animal matter (2.53 percent) eaten by these forms consisted mostly of cutworms, grasshoppers and ground beetles.

A list of 11 bibliographic references is present.



FIELD GUIDE TO LOWER AQUARIUM ANIMALS.

By Edward T. Boardman. Cranbrook Institute of Science, Bulletin No. 16. Bloomfield Hills, Mich. \$1.00 (paper); \$1.50 (cloth). 9 x 6; 186; 1939.

This bulletin was designed primarily "as an easy reference for amateur naturalists and nature counsellors who wish to know what lower animals can be kept in home aquaria." Fishermen will also find this book full of useful information concerning fish food and fish bait. The text

concerns itself mostly with the habitats and habits of these animals, and the illustrations aid their identification. There is a selected bibliography and a glossary.



THE EXTERNAL ANATOMY OF THE LARVA OF THE PACIFIC COAST WIREWORM. U. S. Department of Agriculture. Technical Bulletin No. 693.

By H. P. Lanchester. Government Printing Office, Washington. 10 cents. 9½ x 5½; 40; 1939.

This study forms part of a general program of investigation directed toward the economic control of wireworms in the Pacific Northwest. It is preliminary to comparative studies of the several species of wireworms found in that general section. The later studies will be primarily taxonomic, but based on this morphological study. The descriptions are accompanied by line drawings and the work concludes with a bibliography of 22 titles.



ANIMALIUM CAVERNARUM CATALOGUS. Pars 12, 13, 14.

By B. Wolf. W. Junk, The Hague and 's-Gravenhage. Single copy Dutch Fl. 10.60; subscription price Dutch Fl. 8. 10½ x 7½; 298; 1937-38 (paper).

These numbers of a thorough catalogue of cavern fauna throughout the world contain authors from NOR to SCH, a list of the caves of Yugoslavia, a supplement containing data on phyla found during and after the preparation of the previous parts, and the index for Volumes I to III. Previous parts have been noticed in Vol. 10, p. 104 and Vol. 11, p. 103 of this Review.



UNIVERSITY OF CALIFORNIA PUBLICATIONS IN ZOOLOGY. Vol. 43, Nos. 11, 12, 13. *Organogenesis in the Gasteropod Crepidula adunca* Sowerby, by C. E. Moritz; *The Development of the Heart in the Rat*, by Paul L. Burlingame and J. A. Long; *The Early*

Embryology of Triturus torosus, by J. Frank Daniel and Evangeline A. Yarwood.

University of California Press. 50 cents each. 10½ x 6½; No. 11, 32; No. 12, 72; No. 13, 36 + 8 plates; 1939 (paper).



BOTANY

THE BRITISH ISLANDS AND THEIR VEGETATION.

By A. G. Tansley. The Macmillan Co., New York; The University Press, Cambridge. \$16.00. 10 x 6½; xxxviii + 930 + 162 plates; 1939.

This book is intended to replace *Types of British Vegetation*—published in 1911, and out of print for the last 20 years. Tansley writes in the preface:

The knowledge of our natural and semi-natural plant communities is much wider and especially much deeper than it was in 1911. On the other hand, various problems that we then envisaged as relatively simple have shown themselves upon further study to be very complex indeed and not yet susceptible of satisfactory solution. Thus the writing of this book has been a very different task from the writing of *Types*. In 1911 we wrote practically all we knew and a good deal that we guessed; and though many of our guesses were not far from the truth others have not unnaturally turned out to be wide of the mark.

Although the book has been constructed on the compilation plan it is far more than a compilation, as the reader quickly perceives. The author's very wide knowledge of ecology and extensive experience in appraising available information on British plant communities have enabled him to present a comprehensive treatise which will long serve as a guide for the investigator and student. The 43 chapters (with references) are arranged under the following main headings: The British Islands as environment of vegetation; History and existing distribution of vegetation; The nature and classification of vegetation; The woodlands; The grasslands; The Hydroses: Freshwater, marsh, fen and bog vegetation; Heath and moor; Mountain vegetation; Maritime and submarine vegetation. The numerous illustrations and excellent working index help to make this a standard reference work of the first rank of importance—one that should be made available to all students of ecological problems.

I CEREBALI DELL'AFRICA ITALIANA. I. I frumenti dell'Africa Orientale Italiana studiati su materiali originali.

By Raffaele Ciferri and Guido R. Giglioli. Preface by A. Maugini. Regio Istituto Agronomico per l'Africa Italiana, Firenze. 40 Lire. $9\frac{1}{8} \times 6\frac{1}{2}$; ix + 298 + 1 folding chart; 1939 (paper).

After the conquest of Ethiopia, the Italian government has directed its major efforts to the development of the agricultural production of the country so that it would at least satisfy the local needs and, hopefully, increase the food supply of Italy. Extensive and intensive research in agriculture and the allied branches of science have therefore been greatly encouraged and among others a large scale investigation on grain cereals has been systematically organized. The initial step in this investigation has been a survey of the cereals that have been acclimated in Ethiopia and this monograph is the first of a series of reports on the observations. It is concerned with the taxonomic classification of the species and varieties of *Triticum* found. Altogether 293 varieties are described in full and illustrated. Of this number 97 varieties belong to *T. turgidum abyss.*, 92 to *T. durum abyss.*, 60 to *T. vulgare (ligulatum)* and the remaining belong to *T. dicoccum*, *T. pyramidale*, *T. polonicum* and *T. compactum*. Specimens of other kinds of *Triticum* not heretofore described have also been uncovered but whether they represent stable varieties or simply hybrids will have to be decided by genetic experimentation. The geographic distribution of the species and varieties as well as their frequency are also described. It is a thorough and important contribution to the subject and one which brings to date, extends and also clarifies the observations of Koernicke, Chioyenda, Percival and Vavilov.



EARTH'S GREEN MANTLE. *Plant Science for the General Reader.*

By Sydney Mangham. Foreword by Sir Arthur W. Hill. The Macmillan Co., New York. \$3.50. $8\frac{1}{2} \times 5\frac{1}{2}$; 322 + 40 plates; 1939.

In this popularly written account of plant

life the author discusses with scientific accuracy the various aspects of plants and their relation to the environment. He attempts to give a realization of the true significance of the plant in human affairs. With the aid of photographic and other illustrations, he outlines the story of man's continuous efforts to understand and utilize the wealth of plant life; of the parts played by other branches of science in the development of plant knowledge; and of the use made, and perhaps yet to be made, of such knowledge. He tells something of the history of the use of plants; of the early explorations and discoveries when the search was for spices from the orient, of the sixteenth century immigration of the potato from South America to Europe; and of the Dutch use of marram grass to stabilize sand dunes and cord grass to reclaim shallow lands from the ocean.

An appendix contains suggestions for further reading, and there is a long and complete index.



MAGIC GARDENS. *A Modern Chronicle of Herbs and Savory Seeds.*

By Rosetta E. Clarkson. Illustrated from the Old Herbals and Ancient Gardening Books. The Macmillan Co., New York. \$3.00. $8\frac{1}{2} \times 5\frac{1}{2}$; xviii + 369; 1939.

Magic Gardens has been, perhaps unconsciously, in the making for many years. The author, an ardent herb cultivator at Salt Acres, her place in Connecticut, and editor of the *Herb Journal*, is an assiduous collector of literature on the subject—much of which goes back to very early times. Herein she writes enthusiastically and entertainingly of the 16th century "knotted" gardens of England, the "parterres" of France, the mazes and labyrinths of early Roman and Egyptian times. Detailed descriptions of something over 200 plants are given and their uses in medicine, cooking, potpourris and sachets.

"From undated times herbs of the field have played an almost unbelievably prominent part, not only in the life of the individual in his own home, but in the existence of civilized nations. . . . Today, any fragrant flower or leaf is almost certainly a descendant of an old-time herb."

The volume is illustrated by reproductions from old herbals and prints and concludes with indexes of books and authors, of herbs, and of subject matter.



BOOK OF THE BROADLEAF TREES. *The Story and the Economic, Social, and Cultural Contribution of the Temperate Broad-Leaved Trees and Forests of the World.*

By Frank H. Lamb. W. W. Norton and Co., New York. \$3.75. 8½ x 5½; 367 + 41 plates; 1939.

Anyone who has ever stood under some famous elm or oak and tried to visualize the historic scenes that occurred within sight of its ancient trunk, or anyone who has entered a forest and felt thrilled and somewhat awed at the majestic dignity of its trees will renew these pleasures by reading this book. It is not a scientific treatise on trees, but an account of their history, romance, uses, beauty. The author has travelled widely and his first-hand experience enables him to speak authoritatively. He is acquainted with the Australian eucalyptus and African baobab, as well as with the birches of our North and the live oaks of the South. All those having any interest in broad leaf trees, whether from an economic, scientific, or historic standpoint, will not only find this book interesting but informative. It is well illustrated.



PROPAGATION OF HORTICULTURAL PLANTS.

By Guy W. Adriance and Fred. R. Brison. McGraw-Hill Book Co., New York and London. \$3.00. 9 x 6; ix + 314; 1939.

An excellent text for students in horticulture.

The essential features of plant structure and reproduction have been introduced in their relation to seed production, root formation, wound healing, and other practical phases of plant propagation. The methods of asexual propagation, including bulbs, layerage, cuttage, budding, and grafting are considered in comprehensive form.

Included also are detailed discussions of the propagation of certain important species, such as the peach, plum, apricot, cherry, almond, apple, grape, etc. Sections are devoted to plant diseases, trans-

planting, and the growing and handling of nursery stock. The volume is well documented and illustrated and has an adequate index.



INTRODUCTION TO FLORAL MECHANISM.

By S. G. Jones. Chemical Publishing Co., New York. \$4.00. 8½ x 5½; xi + 274; 1939.

This book, for students in technical colleges and first-year university students, gives a new approach to the study of flowering plants. Emphasis is put on the flower as the *mechanism of inheritance* and the structure, development and functions of flowers are studied from this point of view. Recent developments in cytology and genetics are applied to heredity, hybridization and plant breeding. The latter part of the book (Part II) discusses the keying of a plant to its taxonomic group. This part systematically treats 21 selected families of monocotyledons and dicotyledons. The 70 original, full-page illustrations are finely done and add much to the value of the text. There is a small glossary of terms. The index is well done but the bibliography is brief and not entirely adequate.



EDIBLE WILD PLANTS.

By Oliver P. Medsger. With an introduction by Ernest T. Seton. The Macmillan Co., New York. \$3.50. 8 x 5; xv + 323 + 16 plates; 1939.

In this comprehensive and useful handbook the author describes in detail 69 species of edible fruits and berries, 33 of salad plants and potherbs, 9 of roots and tubers, 11 of sugars and gums, 15 of nuts, 20 of beverage and flavoring plants, 15 of seed and seed pods, and lists many more with brief descriptions. In addition to the regular index and in the place of a key, the author has included an excellent "finding index" which gives the names of plants, both common and scientific, with the range, season, and a few of the most pronounced characteristics. The volume is well illustrated with pen and ink drawings and photographs. There is, however, no bibliography.

LABORATORY MANUAL FOR GENERAL BACTERIOLOGY. Second Edition.

Compiled by George L. Peltier, Carl E. Georgi and Lawrence F. Lindgren. John Wiley and Sons, New York; Chapman and Hall, London. \$2.00. 10½ x 8½; viii + 279; 1939.

This manual, a second edition of a 1938 publication, is concise and comprehensive. There are 57 exercises in all, but the authors intend that the instructor shall make his own selection to suit the particular needs of his class. In this way the manual can be used for classes primarily interested in agriculture, home economics, or sanitary engineering, or for general or pre-medical groups. Descriptive charts, formulae for stains and media, and a bibliography are included.

**AN ILLUSTRATED MANUAL OF CALIFORNIA SHRUBS.**

By Howard E. McMin. With a chapter on *The Use of the California Shrubs in the Garden Design*, by Fred H. Schumacher. J. W. Stacey, Inc., San Francisco. \$5.00. 9½ x 6; xi + 689; 1939.

North of Tehachapi there are more flowering plants than in any other state, and south of them there are more than twice as many. Probably never before has a work covering all of them been undertaken—certainly no more comprehensive work is conceivable. There are 775 illustrations, a glossary, an index, a dictionary of taxonomic terms, and a bibliography, together covering 32 pages, also additional chapters on the ecology of wild plants and their use in the garden. All told, this is a complete work of reference, and every resident of the coast who owns his home should have a copy.

**CHEMICAL INVESTIGATIONS OF THE RHUBARB PLANT.**

By Hubert B. Vickery, George W. Pucher, Alfred J. Wakeman and Charles S. Leavenworth. Connecticut Agricultural Experiment Station, New Haven. Bulletin 424. 25 cents. 9 x 6; 157; 1939 (paper).

Parts I and II of this Bulletin give the

details of separate experiments carried out with rhubarb leaves collected in two successive years from the same farm. The results of the analyses of these leaves, cultured in darkness and in light, are discussed in terms of chemical mechanisms that have been proposed to explain the reactions that may take place in leaf tissues. An interpretation of the data in terms of modern views of plant metabolism has been attempted in Part III. The text is supplemented by numerous tables and there is a complete index.

**VEGETABLE CROPS. Third Edition.**

By Homer C. Thompson. McGraw-Hill Book Co., New York and London. \$5.00. 9 x 6; xi + 578; 1939.

In this edition have been incorporated all the important advances which have been made in the application of scientific facts and principles to the successful production of vegetables and the successful handling of the products since the second edition was issued in 1930. This has frequently involved much revision, especially in such subjects as fertilizer practices, soil reaction, the use of minor or trace elements to control malnutrition troubles, the control of diseases and insects and the packaging, handling, and storage of vegetables.

**SUPPLEMENT TO ROOT NODULE BACTERIA AND LEGUMINOUS PLANTS.**

By Edwin B. Fred, Ira L. Baldwin and Elizabeth McCoy. University of Wisconsin Press, Madison. 50 cents. 10½ x 6½; 40; 1939 (paper).

To supplement the bibliography of 1073 titles in the original volume of *Root Nodule Bacteria and Leguminous Plants* (Q. R. B., Vol. VIII, p. 228) the authors have compiled a new list of: (a) 49 titles omitted in the monograph; and (b) 482 titles of new literature. The supplement also cites 39 errata in the original monograph, and presents two additional indices; one to scientific plant names, and the other to author citations.

ORCHIDS OF MICHIGAN.

By Marjorie T. Bingham. *Cranbrook Institute of Science, Bloomfield Hills, Mich.* Bulletin No. 15. \$1.00 (paper); \$1.50 (bound). 9 x 6; 87 + 22 plates; 1939. The fifty-three different kinds of orchids found in Michigan are described in this bulletin in non-technical language for the lay naturalist. A key to the species follows some introductory notes on their culture, distribution, and conservation. There are many illustrations of these rare plants, some of which are in water color.



KEYS TO THE PHyla OF ORGANISMS: Including Keys to the Orders of the Plant Kingdom.

By Fred A. Barkley. *Associated Students' Store, Missoula, Montana.* 75 cents. 8 x 10½; [4] + 39; 1939 (paper). A useful outline, particularly for courses in plant morphology. The keys were assembled from various sources but especially from the writings of C. E. Bessey and J. H. Schaffner. The contents are divided as follows: A synoptic key to the phyla of organisms, keys to the orders of the various plant phyla, outline of the classification used, glossary, and references.

TEN YEAR PROGRESS REPORT 1928-1938. *Black Rock Forest Bulletin No. 10.*

By Henry H. Tryon. *With an Introduction by C. F. Korstian.* *Black Rock Forest, Cornwall-on-Hudson, New York.* \$1.50. 9 x 5½; iv + 76; 1939 (paper). THE NITROGEN NUTRITION AND GROWTH OF CERTAIN DECIDUOUS TREES OF NORTHEASTERN UNITED STATES. *With a Discussion of the Principles and Practice of Leaf Analysis as Applied to Forest Trees.* *Black Rock Forest Bulletin No. 11.*

By Harold L. Mitchell and Robert F. Chandler, Jr. *Black Rock Forest, Cornwall-on-Hudson, New York.* \$2.00. 9 x 5½; vii + 94; 1939 (paper).

A HIGH-DUTY WOODSAW. *Black Rock Forest Papers, Vol. 1, No. 15.*

By Henry H. Tryon. *Black Rock Forest, Cornwall-on-Hudson, New York.* 11 x 8½; 100-102; 1939 (paper).

MORPHOLOGY

THE RISE OF EMBRYOLOGY.

By Arthur W. Meyer. *Stanford University Press, Stanford University, Calif.; Oxford University Press, London.* \$6.00. 9 x 6; xv + 367 + 58 plates; 1939.

Possibly no other branch of biology has had its history so well presented in our day as embryology; certainly no other branch has a written history which so interestingly displays the errant ways of man in his pursuit of knowledge. In evidence, the latest contribution of Arthur William Meyer may be offered. It aims to trace the growth of embryological ideas, beginning with the ideas on generation held by primitive peoples, and progressing through the ideas of scholars, both early and late, in order to try to discover "why our intellectual ancestors should have been led to entertain views which strike us as absurd" [the words were Huxley's].

If to review past error is one way to avoid future absurdity, this book should be required reading for science students. So, too, the *Quarterly Review of Biology* asserted on the occasion of an earlier publication of Meyer. For students of preformation and epigenesis, the present work is indispensable.

A LABORATORY MANUAL OF VERTEBRATE EMBRYOLOGY. *Anatomy of Selected Embryos of the Frog, Chick, and Pig.*

By F. B. Adamstone and Waldo Shumway. *John Wiley and Sons, New York; Chapman and Hall, London.* \$1.25. 11 x 8½; vii + 87; 1939 (paper).

The interpretation of serial sections is always difficult for the beginning student of microscopical anatomy; and the difficulty is not overcome by drawing a few individual and supposedly representative sections. This new manual outlines a more promising method, as used at the University of Illinois. There the student of vertebrate embryology is required to make only informal sketches in the marginal spaces provided in his laboratory manual, but he is required to study all of the sections in any given series, to identify the structures in them, and to learn to

recognize them by means of their diagnostic features and their relation to each other.



ANATOMY OF THE SHEEP'S BRAIN. A Laboratory Atlas for Students of Zoology.

By E. A. Briggs. Angus and Robertson, Sydney. 6s. net. $8\frac{1}{2} \times 5\frac{1}{2}$; xiii + 50 + 8 plates; 1939.

This brief text and the accompanying illustrations are designed primarily for students pursuing a junior course of practical zoology. The structures described can all be observed with the unaided eye, and the statements have been so formulated as to guide the dissector in making his own observations. No attempt has been made to provide the student with a comprehensive account of all the structural details which he will encounter in a complete dissection of his specimen. The descriptive matter is intended to serve as an introduction to the study of the principal points of interest in the mammalian brain. The book contains a detailed index and also a group of eight excellently-drawn and well-labeled plates which greatly enhance the value of the text as a laboratory manual.



THE ANATOMY OF THE BULL FROG.

By Richard R. Stuart. Denoyer-Geppert Co., Chicago. 50 cents. $11 \times 8\frac{1}{2}$; 30; 1939 (paper).

These thirty-three original drawings made by the author from his dissections of the bull frog, *Rana catesbiana*, should be of excellent visual aid to the beginner in the study of frog anatomy. The drawings are good-sized and simply labeled. As all directions and descriptions are omitted the drawings should be used with at least one descriptive text. The manual is divided into three sections of drawings—skeletal, muscular, and internal. There is a name index.



GUIDE TO THE STUDY OF THE ANATOMY OF THE SHARK, THE NECTURUS, AND THE CAT.

By Samuel Eddy, Clarence P. Oliver and John P. Turner. John Wiley and Sons, New York; Chapman and Hall, London.

\$1.50. 9×6 ; vii + 100; 1939 (paper).

This manual is designed primarily for the course in comparative vertebrate anatomy given at the University of Minnesota, where the type forms are dissected in succession. Because of time limitations, less detailed studies are made on some organ-systems than on others, the muscular and skeletal systems being especially abbreviated.



PHYSIOLOGY AND PATHOLOGY

HEALTH IN HANDCUFFS.

By John A. Kingsbury. Modern Age Books, New York. 75 cents. $7\frac{1}{2} \times 5\frac{1}{2}$; ix + 210; 1939 (paper).

This is a very well written and comprehensive piece of propagandizing on behalf of socialized health insurance. This is not to be confused with socialized medicine. The latter implies universal free medical service supported by general taxation, and seems just as radical a departure for today as our present socialized public school system did when first initiated.

But there is nothing very radical about insurance against impairment of health, or rather the loss caused by it. We can already insure against loss by a multitude of other calamities—flood, fire, lightning, theft, etc., and can purchase disability benefits from many life insurance companies.

In many parts of this country the hospitals are so far apart and the resident physicians so few that insurance providing for hospitalization and medical care has no practical value. To remedy this the Wagner National Health Bill (S. 1620) has been introduced into the Senate. This would provide for government establishment of hospitals where needed and their maintenance, so that their advantages would be readily available to all at a reasonable charge. Opposition to this bill has come chiefly from the American Medical Association—the group who would probably benefit most from its passage, for under it the income of the

physician would be guaranteed, competition would be eliminated, as well as the necessity for the physician to feel the patient's pulse as well as his pulse before diagnosing his case and prescribing treatment.



THE PRINCIPLES OF INSECT PHYSIOLOGY.

By V. B. Wigglesworth. E. P. Dutton and Co., New York. \$8.00. $9\frac{1}{2} \times 6\frac{1}{2}$; viii + 434; 1939.

This new treatise on insect physiology is an outgrowth of the author's small volume entitled *Insect Physiology*, published in 1934. Insects have been intensively studied, and numerous books have appeared on their economic importance, life histories, taxonomy, and recently their morphology. All the experimental research on their physiology, however, has been published in scattered journals, and while much work has been done in this field, no one has ever synthesized the results.

There are in all twelve chapters dealing with the integument, growth, the various organ systems, metabolism, water, and temperature. After each chapter there is an extensive bibliography, so that altogether over 2000 titles are cited. The fact that insects are so varied in kinds and habits makes it necessary to define which creature it is that a particular statement applies to; consequently the text is heavily loaded with generic names.

This book is of great importance to biologists generally. Research workers using insects as subjects of experimentation will attain more precise methods with a sound background in insect physiology. It will also fill a great want for economic entomologists, who in attempting insect control need a knowledge of their physiology in order to strike at the phase in the life cycle that is most vulnerable.

A generous number of illustrations and an index add to the value of this important contribution to zoology.



HORMONES IN INVERTEBRATES.

By Bertil Hanström. Oxford University Press, New York; The Clarendon Press,

Oxford. \$4.25. $8\frac{1}{2} \times 5\frac{1}{2}$; ix + 198 + 13 plates; 1939.

As recently as 1933 the existence of definite endocrine substances and endocrine producing organs in invertebrates was denied by many investigators. In this excellent treatise Hanström has presented a most convincing account not only of the existence of hormones in invertebrates, but also of the specific effects of a number of them on both vertebrates and invertebrates, as well as the effects of various vertebrate hormones on invertebrate organisms. Koller's classification of invertebrate hormones, i.e., (1) 'Zellhormone', (2) 'aglanduläre Gewebshormone', and (3) 'glanduläre Gewebshormone', is considered by the author to be logical and useful in discussing the problem, and the subject matter of the volume has been developed along these three lines. The range of material includes the recent work on the hormones influencing sex, reproduction, metamorphosis, and color change in a wide variety of invertebrate organisms.

The text is carefully organized and well written in clear English. Numerous illustrations pertinent to the subject have been included. The indices of (1) authors, (2) scientific names, and (3) general subject matter, as well as the list of 860 bibliographic references add considerably to the value of this volume as a reference book.



THE VASOMOTOR SYSTEM IN ANOXIA AND ASPHYXIA. *A Study of the Adjustment Reactions of the Mammalian Organism.*

By Ernst Gellhorn and Edward H. Lambert. University of Illinois Press, Urbana. \$1.00 (paper); \$1.50 (cloth). 11 x 8; 71; 1939.

This study deals with the effect of various gas mixtures (1 to 10 percent oxygen and 4 to 15 percent CO₂) on the blood pressure of dogs anaesthetized with sodium amytal, sodium barbital, or chloralosane. Among the significant results are the following:

Under conditions in which carbon dioxide and oxygen deficiency cause a rise in blood pressure, i.e., in the normal dog with and without artificial respiration, and further after vagotomy or removal of both carotid sinus areas with artificial respiration, the effect of carbon dioxide plus low oxygen tension is

greater than corresponds to the algebraic sum of the individual effects.

In the dog deprived completely of its buffer nerves and artificially ventilated, it is found that carbon dioxide completely offsets the fall of blood pressure produced by the inhalation of a gas with a low oxygen tension.

The experiments indicate that the cause of this potentiation lies in the fact that the effect of carbon dioxide is increased in anoxia. This is in part due to the weakening of the carotid sinus pressor reflexes. In addition to that it is assumed that the intracellular metabolites formed during short periods of anoxia may interact with the effects of carbon dioxide and thereby cause the potentiating effect described above.

There is a bibliography of 152 titles.



THE STATISTICS OF PULMONARY TUBERCULOSIS IN DENMARK 1925-1934. *A statistical investigation on the occurrence of pulmonary tuberculosis in the period 1925-1934, worked out on the basis of the Danish National Health Service file of notified cases and of deaths.*

By Marie Lindhardt. Ejnar Munksgaard, Copenhagen. Kr. 8. 10½ x 7; 179 + 1 folding table; 1939 (paper).

The present investigation was undertaken on the basis of the file of consumptives kept by the Danish National Health Service. These tuberculosis notifications, which since 1920 have been regularly treated statistically, have been collected under a rational filing system since 1925. The present investigation comprises 39,379 notifications of new cases received by the National Health Service between 1925 and 1934, and 20,173 notifications of deaths occurring in the same period. In this report the distribution of tuberculosis in various parts of the country according to age, sex, civil status, etc., and its nature, duration, lethality, seasonal fluctuations, and incidence within various groups are thoroughly discussed and illustrated with numerous graphs and tables. Supplementary tables are included in the appendix, and there is an extensive bibliography.



THE VITAMINS. *A Symposium Arranged Under the Auspices of the Council on Pharmacy and Chemistry and the Council on Foods of the American Medical Association.*

American Medical Association, Chicago.

\$1.50. 8½ x 5½; 637; 1939.

VITAMIN D. *Chemistry, Physiology, Pharmacology, Pathology, Experimental and Clinical Investigations.*

By C. I. Reed, H. C. Struck and I. E. Steck. *University of Chicago Press, Chicago.*

\$4.50. 9 x 6; xviii + 389; 1939.

A good summary of a field of work, and a detailed report on any part of that field are always of value. These two books are admirable examples. The vitamin symposium, arranged under the auspices of the American Medical Association, numbered 30 authorities among its participants; it presents a digest of what is known about each vitamin. This book gives the reader a fairly comprehensive idea of the importance of vitamin therapy in modern medicine.

The second book is a résumé of what is known about Vitamin D, and a working report from a laboratory active in its study. Scientists, teachers, industrialists, druggists, and physicians will find this a dependable reference. Both books are careful to make it clear that the field of vitamin study is far from being worked-out, and that there is much to be done before what is known can be applied to best advantage.



DIE FUNKTION DER NEBENNIERENRINDE.

By F. Verzar. Benno Schwabe and Co., Basel. 25 Swiss francs. 8½ x 6; 266; 1939.

In this attractively printed volume the professor of physiology in the University of Basel presents a comprehensively thorough, critical review and synthesis of the literature on the function of the adrenal cortex, in which the results of his own important work in this field are clearly set forth and brought into their proper place in the general picture. It is now certain that cortin, the hormone of the adrenal cortex, is a substance of fundamental importance in the metabolism of the cell generally. Lack of this hormone starts a train of changes in fat metabolism, and in carbohydrate formation in the cell that lead finally to failure of heat regulation, of selective glucose resorption, of glycogen formation in the liver, of K elimination

by the kidney, loss of plasma from the blood, and death.

In its logical, clear, and concise elucidation of an extremely complicated field this book is a masterpiece. The bibliography, set in the most condensed form, occupies 30 pages and covers the literature to 1939. A valuable addition to any biological library.



STUDIES IN THE PHYSIOLOGY OF THE KIDNEY. *Porter Lectures, Series IX. Delivered at the University of Kansas School of Medicine.*

By Homer W. Smith. *University Extension Division, University of Kansas, Lawrence.* \$1.00. 8 $\frac{5}{8}$ x 5 $\frac{3}{4}$; [6] + 106; 1939. The first lecture in this series is concerned with the physiological bases of recently developed methods for examining the normal and diseased kidney, such as functional methods of measuring the glomerular filtrations, the renal blood flow, and the quantity of intact, active glomerular and tubular tissue. In the second lecture the general evolutionary history of the vertebrates is discussed with special reference to the kidney of fishes. The final lecture on the renal blood flow in normal and hypertensive subjects, deals largely with experimental work, such as the effect on renal function of various substances (oil of juniper, adrenin, ephedrine), vasodilatation of the renal arterioles, relationship of renal arterioles and the nervous system. In this section is given a chart "summarizing the more important data in renal function as found in 15 hypertensive subjects." A number of diagrams and figures will be found in the volume, each lecture is well documented, but no index has been provided.



THE FLOWERING OF AN IDEA. *A Play Presenting the Origin and Early Development of The Johns Hopkins Hospital.*

By Alan M. Chesney. *The Johns Hopkins Press, Baltimore.* \$1.50. 8 $\frac{1}{2}$ x 5 $\frac{1}{2}$; 87; 1939.

Written for the celebration of the fiftieth anniversary of the opening of The Johns Hopkins Hospital, the story of this play centers about the origin, early development and formal opening of the hospital. The play, in four scenes, is admirably adapted for just such a formal occasion. The first scene, wherein an imaginary conversation takes place between Johns Hopkins and George Peabody concerning the uses to which they intend to put their money, gives the author a chance to show the interesting personalities of these two men. The dialogue throughout the play seems somewhat stilted, but this stiffness of style is partly a true characteristic of the times portrayed, and partly to be attributed to the fact that, with the exception of the first scene, official records and documents were closely followed.



ZÖOLOGICA. *Scientific Contributions of the New York Zoölogical Society. Volume XXIV, Part 3, Numbers 10-26.*

New York Zoölogical Society, Zoölogical Park, New York. \$2.00. 10 $\frac{1}{2}$ x 7; 120 + 22 plates; 1939 (paper).

This issue of *Zoölogica* reads much like a number of the *Journal of the American Medical Association* and for this reason we have put this review in "Physiology and Pathology". Of the 17 papers, 14 form the bulk of the report of the Hospital and Laboratory of the New York Zoölogical Park for 1938. The first number gives a résumé of the causes of death in the collection. As a basis for this, the International Classification of Causes of Death adopted for man by an International Committee in 1929 is used, although some modification has been necessary to exclude those diseases to which animals are immune and to include those diseases which attack only animals. Other papers deal with carcinoma of the pancreas in a bear, goiter in a dromedary, dental pathology, parasites of wild rats, *Multiceps serialis* infestation in a baboon, amoebic dysentery in an orang-utan, etc. All of the papers carry bibliographic references and many excellent photographs add to the interest of the texts.

PRINCIPLES AND PRACTICE OF AVIATION MEDICINE.

By Harry G. Armstrong. Williams & Wilkins Co., Baltimore. \$6.50. 9 x 6; xii + 496; 1939.

Progress in aviation has been accompanied by the increased realization that new kinds of medical problems arise from the unusual environment in which the flier finds himself. To deal particularly with such problems a specialized branch of medicine is now in the process of being definitely formed. The author has brought together and examines in this volume most of the available literature on the several phases of the subject. The first nine chapters are concerned with the selection of pilots, the physical and psychic requirements they should possess, the standards of examination used in this and other countries. The remaining twenty-nine chapters deal with the evidence so far collected on the physiological, psychological and pathological manifestations associated with flying. Although necessarily sketchy in parts the book covers well the whole vast range of the subject and contains an excellent bibliography.



NUTRITION AND DIET IN HEALTH AND DISEASE. Third Edition, Entirely Rewritten.

By James S. McLester. W. B. Saunders Co., Philadelphia and London. \$8.00. 9½ x 6; 838; 1939.

In the twelve years which have elapsed since the first appearance of this book "newer discoveries have been so far reaching and the changes in the point of view so extreme" that it has been necessary completely to rewrite this edition. Only occasional paragraphs have been retained, such as those dealing with Sippy's method of treating peptic ulcers. A relatively large amount of space has been given to the nature and physiologic influences of the several nutritive substances and to the discussions of disordered physiology.

Part I deals with nutrition in health (3 sections, 314 pages); Part II, with nutrition in disease (436 pages); Part III, appendix (ca. 60 pages) contains

considerable tabular matter. The volume is thoroughly documented and indexed. Teachers and practicing physicians will find this a dependable guide.



LIQUOR, THE SERVANT OF MAN.

By Walton Hall Smith and Ferdinand C. Helwig. Little, Brown and Co., Boston. \$2.00. 8 x 5½; [4] + 273; 1939.

This volume presents a sound and unbiased review of much of the more important scientific work that has been done on the biological effects of alcohol. The style of writing will probably offend some readers, for the same kind of reason that baby-talk from aged spinsters is irritating to some people. But leaving this aside, the reader of this book, which is the product of the collaboration of a professional writer and a pathologist, will get a just picture of what is presently known about the ways and degrees in which alcohol affects physiological, psychological, and pathological processes in man. Much of it will be new, even to the biologist who has not himself actually worked in this field. The book has no index, which is a pity, because its organization lacks that kind of precision that might help in using it for reference purposes in the absence of an index.



AN INTRODUCTION TO MEDICAL MYCOLOGY.

By George M. Lewis and Mary E. Hopper. Year Book Publishers, Chicago. \$5.50. 10 x 7; xviii + 315; 1939.

This text has been designed to give the student a substantial knowledge of the important phases of mycology and of the common fungus diseases. The characteristics and habits of the habitual fungus parasites are briefly but clearly described. Since the pathogenic flora varies in different parts of the world, "our emphasis on certain fungi as important in New York may not apply to the same degree in other localities." The first part deals with clinical, theoretical and experimental aspects of the subject; the second, with laboratory procedures useful in examining a

patient suspected of having one of the various mycoses. The bibliographies accompanying each section are not complete but contain "articles which we think are important for their originality and their value in teaching." There is an index.



THE JOURNAL OF ENDOCRINOLOGY. *Volume I, Number 1.*

Edited by E. C. Dodds. Oxford University Press, London and New York. Subscription price: 30s. or \$6.00. 10 x 6½; 116; 1939 (paper).

This new quarterly is founded to bring together and to make available in a single British journal papers in the English language concerning "the internally secreting glands, the mode of their actions, the nature of their secretions, and the disorders of their functions." Contributions from all countries will be welcome. Papers intended for publication should be submitted to the editors at the Courtauld Institute of Biochemistry, Middlesex Hospital, London, W. 1. The editorial board includes P. M. F. Bishop, C. R. Harington, G. F. Marrian, A. S. Parkes, F. G. Young, and S. Zuckerman.



THE ENDOCRINE GLANDS.

By Max A. Goldzieher. D. Appleton-Century Co., New York and London. \$10.00. 9½ x 6½; xvi + 961; 1939.

It is the announced aim of this book to discuss systematically and thoroughly, and on the basis of first-hand information, both the theoretical and the practical aspects of endocrinology, and to abstract from the enormous literature the really important contributions which have a bearing on the practice of the clinician. Endocrinology is still a very rapidly changing field, of course. The author has not always succeeded in passing unprejudiced judgment on which contributions are clinically most important. He has succeeded single-handed, however, in marshalling a prodigious array of detailed matter in a masterly fashion. A selected bibliography follows each chapter.

HYDROPTHALMIA OR CONGENITAL GLAUCOMA: *Its Causes, Treatment, and Outlook.*

By J. Ringland Anderson. With a Foreword by Sir John Herbert Parsons. The University Press, Cambridge; The Macmillan Co., New York. \$7.00. 9½ x 6; xx + 377; 1939.

The last monograph on this subject was published in 1897. This book will therefore serve as a summary of the literature for the practicing ophthalmic surgeon. The first portion of the work deals with the pathology, morphology, and diagnosis of the disease. The remainder of the book is given over to methods of treatment and surgical techniques. Each chapter has appended a long bibliography of titles down to 1938. The tables inserted in the back cover of the book contain the data for each case discussed in the text. The work is well illustrated.



HUMAN HELMINTHOLOGY. *A Manual for Physicians, Sanitarians and Medical Zoologists. Second Edition, Thoroughly Revised.*

By Ernest C. Faust. Lea and Febiger, Philadelphia. \$8.50. 9½ x 6; 780; 1939.

This excellent and exhaustive presentation of the science of helminthology by one who for many years has been a teacher and investigator in the field first appeared ten years ago (cf. Q. R. B., Vol. 5, p. 248). In this second edition, new illustrations have been added, bringing the total to 302, and old ones have been revised and clarified. A new chapter on "Anthelmintics and Their Use" has been included, and the terminology in the book has been brought up-to-date. The extensive bibliography is placed at the end instead of being included in the individual chapters. There is both an author and subject index.



AN INTRODUCTION TO GASTRO-ENTEROLOGY. *Being the Third Edition of The Mechanics of the Digestive Tract.*

By Walter C. Alvarez. Paul B. Hoeber, Medical Book Department of Harper and Bros., New York and London. \$10.00. 10 x 7; xxii + 778; 1940.

This third edition of a well-known and valuable treatise is in reality a new book,

entirely rewritten and about double the size of the second edition which appeared in 1927 (cf. Q. R. B., Vol. 3, p. 450). Seven new chapters have been added and data from about 1500 new articles and books have been included. Summaries have been prepared for each chapter, and a chapter on "books and reading" lists works that will be helpful to young men who are starting their lifework in the fields encompassed by this book. The book is illustrated, and equipped with a bibliography of 114 pages and an index.



EVANS' RECENT ADVANCES IN PHYSIOLOGY.
Sixth Edition.

Revised by W. H. Newton. *The Blakiston Co., Philadelphia.* \$5.00. 7 $\frac{3}{4}$ x 5 $\frac{1}{4}$; xi + 490; 1939.

Much of the material in this edition has been carried over from the 5th edition (noticed in Q. R. B., Vol. 11, No. 4) and brought up to date. Several new chapters are included dealing with: (a) the physiology of bone, (b) the Carrel-Lindbergh perfusion apparatus, (c) problems of carbohydrate metabolism, (d) the cortical control of muscular movement.



HEALTH FOR NEW YORK CITY'S MILLIONS.
An Account of Activities of the Department of Health of the City of New York for 1938 with Comparative Vital Statistics Tables.

By John L. Rice. *Department of Health, City of New York, 125 Worth Street, New York.* Free to libraries, schools of public health and to special organizations. 9 x 6; 295; 1939.



BIOCHEMISTRY

EXPOSÉS ANNUELS DE BIOCHIMIE MÉDICALE.
Deuxième Serie.

Published under the Direction of Michel Polonovski. *Masson et Cie, Paris.* 75 francs. 9 $\frac{3}{4}$ x 6 $\frac{3}{4}$; [4] + 264; 1939 (paper).

Like the first volume of this annual (cf. Q. R. B., Volume 14, p. 376) this number includes a group of excellent papers by

leading workers which should be of interest to medical practitioners and biochemists. Included are: Contributions to biological oxidation at the cellular level, by A. Szent-Györgyi; Physiological methods of the estimation of pre-deficiency states, by E. J. Bigwood; The glucides of the nerve centers, by A. Baudoin; Chemical constitution of the diastases, by M. Polonovski; Virus proteins, by Ch. Sannié; Immuno-chemistry, by M. Macheboeuf; Magnesium in biochemistry, by M. Wolff; Composition of natural phosphorus compounds and their metabolism, by P. Fleury; Cortico-suprarenal hormones, by P. Boulanger; Uric acid, by G. Florence; Rôle of nitrates in cellular metabolism, especially in the higher plants, by M. Lemoigne; and Some biochemical problems posed by ossification, by J. Roche.



BIOMETRY

PROCEEDINGS OF THE INDUSTRIAL STATISTICS CONFERENCE held at Massachusetts Institute of Technology, Cambridge, September 8-9, 1938.

Pitman Publishing Corp., New York and Chicago. \$2.50. 9 $\frac{1}{8}$ x 6 $\frac{3}{8}$; [5] + 315; 1939.

This book comprises the lectures of several well-known statisticians and mathematicians on the subject of control of quality and standardization of product in industrial plants; also the application of statistical methods to research in medicine and various other fields. It is obvious that statistical control of the quality of raw materials, the behavior of machinery, etc. in large industrial plants is necessary for a more or less thorough understanding of what is taking place. It inevitably leads to better finished products, and better methods of production, which of course reduces the percentage of rejection and leads to lower cost to the consumer.

The lectures in this book explain clearly the present value and future possibilities of the use of statistics in the manufacturing world, draw attention to methods of analysis of scientific data, and also illustrate somewhat to the uninitiated the use of statistics as the safe method of proving

a fact or exploding a fallacy. A careful reading of the report may be of value in helping to solve problems along the lines indicated.



GRAPHIC PRESENTATION.

By Willard C. Brinton. *Brinton Associates*, New York. \$5.00. 9 x 6; 512; 1939.

For many years Brinton has been the leading authority in this country on the graphic representation of statistical data. His *Graphic Methods* (1914) is the standard text on the subject. It is doubtful that the present volume will add greatly to his reputation. It is, in essence, a modernized, stream-lined, and somewhat jazzed-up re-treatment of the material, obviously influenced by present-day graphic technique in the advertising field. While every statistician will want it at hand for reference and student use, it will not wholly replace the author's earlier text. Free use of color, and great originality and ingenuity in the make-up and arrangement, make it a striking book. It is well indexed, and thoroughly documented throughout.



THE BULLETIN OF MATHEMATICAL BIOPHYSICS. Volume 2, Number 2, June, 1940.

Edited by N. Rashevsky. Editorial and Publication Offices, 5822 Drexel Avenue, Chicago.

This number contains the following papers: The equivalence of the conduction theories of Rashevsky and Rushton, by Alvin M. Weinberg; Further contributions to the theory of cell polarity and self regulation, by N. Rashevsky; Contributions to the mathematical theory of organic form: II. Asymmetric metabolism of cellular aggregates, by N. Rashevsky; A contribution to the mathematical biophysics of psychophysical discrimination III, by H. D. Landahl; Nerve conduction theory: Some mathematical consequences of Bernstein's model, by Alvin M. Weinberg.

THE UNIVERSITY OF COLORADO STUDIES. General Series (A), Volume 26, Number 2. Containing the Following: *What is the Nature of Mathematics, and in what sense does Mathematics explain a Science?*, by Aubrey J. Kempner; *Abstracts of Theses and Reports for Higher Degrees, 1939.*

University of Colorado, Boulder. \$1.00. 10 x 6 $\frac{1}{4}$; 134; 1939 (paper).



SEX

MOEURS NUPTIALS DES BÊTES.

Various Authors. Preface by Jean Rostand. Editions Stock, Paris. 25 francs. 7 $\frac{1}{2}$ x 5 $\frac{1}{8}$; 306; 1939 (paper).

Some years ago there was mention in these columns of a contemplated treatise on *The Natural History of Copulation*, to be published in elephant folio abundantly illustrated with plates in the best tradition of zoological publication in the good old days. The present volume contributes to this worthy project by furnishing ready-made a text for the treatise, written with the sort of clarity and charming grace that French writers seem to command so much more frequently than those of other countries.

The general editor of the volume is Jean Rostand, who is probably the world's foremost popularizer of biology today, taking the whole range of pertinent values into account. Associated with him in the production of the volume are such well-known zoologists as Lucien Berland, who does the sections on the crustaceans, arachnids, and insects; L. Bertrand (fish); F. Angel (reptiles); J. Berlioz, who shares the section on birds with Jacques Delamain and Jean de Bosschère; Andrée Martignon, Jean-Émile Benech, Denyse de Stampa, G. Petit, E. Gromier, Marquis de Barthélemy, and Dr. Laurent, who between them take care of the love life of the mammals. M. Rostand, in addition to a delightful preface, does the sections on the infusoria, worms, molluscs, and batrachians.

The book is characterized by the utmost delicacy of language, but what it is all about is copulation, and nothing much else. It is extremely well done. While

intended for the general reader of the lay public, the professional biologist will find it an excellent review and digest of the main features of an interesting section of the animal behavior field.

Space is lacking to discuss particular points in any detail. The statement is made that while the preliminary courtship behavior of whales has been fairly frequently observed, their actual copulatory act has probably never been seen. A sketchy and not altogether satisfactory or convincing account is given of a single observation of the copulatory behavior of wild elephants in the wild. This has been very rarely observed; some experienced men who have devoted their lives to the study of elephant behavior say never.

The volume is well indexed and can be recommended as an addition to any biological library.



LOVE PROBLEMS OF ADOLESCENCE.

By *Oliver M. Bunkerfield*. *Emerson Books*, New York. \$2.25. 9 x 6; viii + 212; 1939.

Some 1100 youths of both sexes ranging in age from 13 to 25 years listed, on request, the sex and matrimonial problems about which they desired information. The youths belonged to 24 separate organizations, the majority being under the auspices of Protestant churches. The inquiry shows that the questions most frequently asked regarded the propriety of juvenile heterosexual relations such as kissing and petting, while those relative to the advisability of establishing boy and girl friendships when there are differences in age and education were encountered with the least frequency. However, as can be expected due to the wide age range among the subjects, there is a considerable variation from group to group in the type of questions asked. The author discusses the results as indications of the need for more education in matters of sex relations and sex hygiene. He concludes:

We live in an age of educational and factual abundance but we appear to suffer great privation from a poor distribution of its resources. The hope for improvement lies in attacking the situation all along the line

with special stress upon the training of parents. Pre-marital and post-marital adult education can take up much of the lag and thus in the next generation greatly reduce the present perplexities due to ignorance.

This type of reasoning is based on the false premise which identifies theoretical with practical knowledge and culture with wisdom. Lectures and books cannot solve the immediate perplexities of a 13-year-old first adventuring into sex relations, no more than it can for one first attempting to drive an automobile or a train. Is it possible that the educators have not yet realized the implications of the methods of Montessori and of Froebel which they have accepted?



WOMEN AND MARRIAGE IN INDIA.

By *P. Thomas*. *George Allen and Unwin*, London. 7s. 6d. net. 7½ x 5½; 224; 1939.

With all the fire and heat of a 19th century militant suffragette the author attacks the marriage system in India and the moral theology on which it is based. To the complaisant subjection of the woman are ascribed the current ills of the country and the lack of competent leadership. Therefore, if India is to take its place in the sun the status of the woman and the prevalent form of social relationship between the sexes must be altered. The author advocates a number of reforms including the abolishment of child marriages, the establishment of the right to divorce, greater freedom of contact between the sexes, and their equality in all matters even to include the right of the wife to half of her husband's pay. Such views sound reasonable from the standpoint of our civilization and one ordinarily would be ready to cheer on the efforts to bring about such reforms. It is unfortunate, however, that this book does not evoke sympathy—due to the author's vituperative style and strange concepts of Western customs. It seems that among other objectionable qualities the Indian husbands spend a good deal of their time at home. In a characteristic manner the author assails violently such habits as the following:

Whenever the robust European woman finds her husband too home-loving or sentimental, she manages to nag him into his club or the cricket-field. But her Indian sister is too much a Pathivrita to do anything of the sort. She stands dutifully on the balcony from 5 P.M. onwards, watching her lord come home from office, tries to smile and look pleasant when he comes, proceeds to undress him, puts him to bed, presses his lean limbs and long head, feeds him out of her hand, and generally makes him the voluptuous imbecile he is. Many of the children produced in these homes are morons ending up in the street or on the banks of the Ganges.



LES HERMAPHRODITES ET LA CHIRURGIE.

By L. Ombrédanne. Masson et Cie, Paris.

85 francs. 10 x 6½; 322; 1939 (paper).

In the case of hermaphroditism when should the surgeon intervene for corrective purposes and on the basis of what criteria should he decide to increase either the masculine or feminine appearance? These problems constitute the main theme of this volume which includes also a general survey of hermaphroditism in its embryological, morphological and physiological aspects. However, the major portion of the book is devoted to the clinical and pathological variations of persons with (a) male gonads and external feminine appearance and (b) female gonads and external masculine appearance. He considers also the question of the marriage of such persons and the views of the law and of moral theology on the subject. In great detail he describes twenty-two cases he himself observed, their personal history, the operative findings, and the reasons for the particular procedure he followed. He apparently believes that no attempt at correction should be made until puberty is passed and then surgery should usually be employed to change the form of the external genitalia so that they agree with the sex of the gonads. However, as he illustrates with his own material, there are often cases in which it is impossible or unwise to follow this rule and then the operator is legally and morally justified to change the genitalia so that they harmonize with the patient's external somatic appearance, psychic reactions and desires.

ATTAINING WOMANHOOD. *A Doctor Talks to Girls About Sex.*

By George W. Corner. Harper and Bros., New York and London. \$1.00. 7½ x 4½; xiii + 95; 1939.

Dr. Corner again "rings the bell" with this little volume for adolescent girls. Like its companion forerunner, *Attaining Manhood*, the facts of life are presented in simple, non-technical language, yet accuracy and clearness is maintained. This is a good example of how the simple truth, neither brutally frank nor evasive, can easily furnish an answer to that parental bugbear, the baffling question of what and how the children shall be taught about sex.



PSYCHOLOGY AND BEHAVIOR

BEYOND THE CLINICAL FRONTIERS. *A Psychiatrist Views Crowd Behavior.*

By Edward A. Strecker. W. W. Norton and Co., New York. \$2.00. 8 x 5½; 210; 1940.

There seems to be something of a trend at the present time for the clinical psychiatrist, with his experience in the intra-individual chaos presented by the psychoses and psychoneuroses, to extend his authority to the international situation with its chaos between individuals *en masse*, and to attempt to analyze the latter in terms of the former. There is a certain validity in such a critical evaluation, if not too much is said and the analogy is not drawn beyond the facts. Such an evaluation is attempted in this book, which comprises the Salmon Lectures for 1939, by Dr. Strecker, Professor of Psychiatry at the University of Pennsylvania. Outlining the similarities between the behavior of the normal individual, the mentally ill individual and the crowd or mass-man, he draws a parallel between the short-circuiting of reality by the psychotic and the mob, "Unquestionably, the world is sick—mentally sick," he states, and the temptation to ignore the checks of the intelligent minority and to utilize the escape technique of the crowd mind is becoming

stronger. In recruiting intelligent minorities who will be effective in holding the balance of power and effecting satisfactory compromises when conflicts with the primitive forces of the mass-man arise, lies Strecker's hope for civilization. This, he thinks, can be accomplished only through a broad extension of the principles and practices of mental hygiene. His observations are perspicacious and succinctly put, and the fact that they are platitudinous is perhaps inescapable. The lectures were perhaps better heard than read: this reviewer found the rather random arrangement of the material and case extracts into loose paragraphs distracting. The significance of this book would seem to be in its place as part of the trend towards an ultimate understanding of crowd behavior in terms of human personality.



WAR AND PEACE. *Essays in Psychological Analysis.*

By William Brown. A. and C. Black, London. 5s. net. $7\frac{1}{2} \times 5\frac{1}{8}$; xvi + 93; 1939.

This book by the English psychiatrist, William Brown, was written in the spring of 1939, after the peace of Munich but before the actual outbreak of war in Europe. It is understandable that, at so critical a time as this, this philosophically-minded physician who had seen active service during the four years of the last war should feel impelled to express his views on the basis for and prevention of war. He does so in this small book of seven chapters, each a short essay emphasizing a particular feature of the central thesis that war is implicitly determined and the result of primitive aggressiveness and hostility repressed in the depths of the unconscious mind. Logically, therefore, the problem of avoiding war is to find adequate sublimation for these tendencies. This general thesis is developed by the author in a rather platitudinous and rambling fashion which does not come to any constructive point. The suggestion that all public leaders increase their self-knowledge, presumably through

psychoanalysis, is made. The author affirms his faith in Prime Minister Chamberlain and in a new League of Nations. Peace, he states, will be reached "only by a deep analysis followed by a process of sublimation wherein the ideals of different nations may combine in the one ideal—a super-national ideal of free cultural and spiritual development of all human beings, whatever their nationality, each within his own national sphere and environment."



INTELLIGENCE AND CRIME. *A Study of Penitentiary and Reformatory Offenders.*

By Simon H. Tulchin. University of Chicago Press, Chicago. \$2.00. 9 x 6; xiii + 166; 1939.

This monograph presents the results obtained from intelligence tests administered to over 10,000 inmates of 3 Illinois penal institutions during the years 1920-27. The same procedure and the same tests as those given by the army to draft recruits were employed in this study so that the data on the Illinois recruits could be used for comparative purposes. The main finding is that, on the whole and also when nativity and race (color) of the prisoner are taken into consideration, the intelligence scores of the criminals do not differ appreciably from those of the recruits. When the criminals are segregated according to type of crime committed, the highest score, on the average, was made by those who committed fraud while the score was lowest for sex criminals. This is to be expected. The author has also analyzed the data in terms of age, nativity, race (color), education, height and weight and the results are similar to the findings of others. Of interest and apparently inexplicable for the author are the higher scores of the recidivists when compared to first-termers. Maybe the intelligence is here manifest by the ability to get a short prison sentence or an early release from prison. Although the statistical presentation of the results is not of the best, these findings certainly do not reinforce the position of those that believe that education can

eliminate crime or that criminals are all feeble-minded.



MIND EXPLORERS.

By John K. Winkler and Walter Bromberg. Reynal and Hitchcock, New York. \$3.00.

8½ x 5½; [4] + 378; 1939.

The development of psychology as a science, and of psychiatry, from the 18th century when interest in human nature first became widespread and objective to the present day, is presented in this book in a series of excellent biographic sketches of the investigators whose contributions and influence have been most significant. With a chapter each devoted to the more dramatic Gall and Mesmer, it is to be regretted that the brilliant treatises of the still earlier students, Locke, Hume, and Bentham are not mentioned. However, the names selected provide a comprehensive survey of important advances on many fronts: Pinel, Eli Todd, Charcot, Francis Galton, William James, Stanley Hall, Cattell, Terman, Yerkes, Thorndike, Lashley, Watson, Freud, Adolf Meyer, and Clifford Beers. The contributions of each of these men as a logical outcome of his own personality and experience makes fascinating reading, and the interlocking of influence from man to man and country to country welds the mass of information into an intelligible historical whole. The book gives a clear, critically well-evaluated formulation of the genetic-dynamic development of the rapidly expanding sciences of human personality function. There is a short, well-selected list of important references.



THE MIND OF THE BEES.

By Julien Françon. Translated by H. Eltringham. Methuen and Co., London.

6s. net. 7½ x 5½; xi + 146; 1939.

Most of the studies on insect behavior have been confined to the laboratory where conditions are likely to be just about as unnatural as possible. This, however, is not the case in this excellent study of bees by M. Françon. Many

years of field observation and ingenious experimentation in nature have convinced the author that the bees have a remarkable ability to communicate to one another precise directions as to the position and availability of certain materials valuable for the production of honey. M. Françon also believes that the economy of the hive is such that extra workers may be regimented at a moment's notice when the value of the "find" seems to warrant it, and that the number of extras put on the job is accurately proportioned in relation to the distance from the hive, and the quality of such a "find".

The book is clearly and simply written. It will be read with great interest, not only by bee-keepers, but also by entomologists in general whose interests lie in the field of animal behavior.



THE LIFE AND DEATH INSTINCTS (*The Vita and the Fatum*).

By Arthur N. Foxe. *The Monograph Editions*, 25 West 54th St., New York.

\$2.00. 8 x 5½; 64; 1939.

In this rambling, verbose little volume, Dr. Foxe purports to offer a psycho-analytic examination of the *vita* and the *fatum*. At least three etiological factors are alleged to be involved in the formation of the *criminoses*:—a severe trauma sustained in infancy or early childhood, a real want or need that cannot be satisfied in the home, and the hidden participation of other members of the family in the *criminosic* behavior. The author also expresses himself concerning chance and determinism, war and peace, transference and recognition, and the interplay of the *vita*, the *libido*, and the *fatum*. There is a bibliography, but no index.



DE OMNIBUS REBUS ET QUIBUSDEM ALIIS

MODERN SCIENCE. *A Study of Physical Science in the World Today.*

By Hyman Levy. *Diagrams* by Joan Samuëll. Alfred A. Knopf, New York.

\$5.00. 9½ x 6½; x + 736; 1939.

Within the last 15 years a succession of books has appeared, each, as Prof. Levy points out, more startling than the previous, in which science is presented in mysterious garb. This has been to invert its true purpose. If science means anything it entails clearing the atmosphere by reducing it to reason and finally it and common sense to a common denominator. This volume has been written "to present a balanced picture of the whole . . . [and] to attempt to picture the goal towards which the present crisis is converging."

An understanding of the scheme of the book is important. Part I, The energy of man, discusses the background of social life within which science has developed.

"Today the ferment among scientific men is stimulated by the same disillusionment as urged on the Encyclopaedists; historically, however, it must be seen as the next stage of the ferment of the seventeenth century in this country [England]. It is disillusionment *after* the Industrial Revolution; it is the drive to advance science beyond the mere study of nature at the level of inanimate matter, to the level of men in their group activity." The new division of the British Association "to explore the social relations of science is a step in the rational process of paving the way to the new society."

Part II deals with the coming of the machine and attempts to explain and clarify the general ideas which were the outgrowths of this phase. "It shows how the mind of man was affected in its thinking by the machine he was creating."

Part III discusses "groups or systems of things, ideas, events that can be made to show a pattern or an orderliness in their arrangements." It treats of the historical development and use of numbers, and "the struggle for mental freedom and expression in mathematical form." This section, which concludes with The language and measurement of movement:—the calculus, and problems of the calculus, will have special significance for the mathematician. The headings of the last four parts are: Newtonian laws; The perfection of shape [one of the chapter headings of this section is Shaking off the past.—The sad story of Euclidean geometry]; What is the universe?; and The age of

light; with an epilogue, Science in travail.

One hundred and fifty-four diagrams aid in clarifying the text. The volume is not documented but has an adequate index.



A SHORT HISTORY OF SCIENCE.

By W. T. Sedgwick and H. W. Tyler.

Revised by H. W. Tyler and R. P. Bigelow.

The Macmillan Co., New York. \$3.75.

8½ x 5½; xxi + 512 + 9 plates; 1939.

This text, intended for a beginner's course in the history of science, embodies the development of scientific thought from the time of the earliest recording of ideas down to about the end of the nineteenth century. To include such a vast amount of history in one volume is an enormous task, and the discussion of any particular phase of science must of necessity be very brief. The progression of events in the physical sciences, and particularly mathematics, is somewhat more detailed than that of the natural sciences.

The writers state specifically that there is no attempt at completeness. This fact is most severely felt in that the progression of scientific ideas and discoveries is not correlated with the progression of other historical happenings. This lack of correlation in the textual material is, however, somewhat compensated by the chronological listing of some important dates, names, and events in Appendix B. Appendices A and C list, respectively, some inventions of the eighteenth and nineteenth centuries, and a small number of reference books in the history of science.

The volume is generously illustrated and comprehensively indexed.



SCIENCE TODAY AND TOMORROW.

By Waldemar Kaempffert. The Viking

Press, New York. \$2.50. 8½ x 5½; 275;

1939.

The advance of science up to the present day, and its possibilities for the future are clearly presented for the lay reader of this volume. The early chapters discuss the solar system, the question of its

origin, and the possibility of interplanetary travel. Next the problem of power is considered. When the world's supply of coal is exhausted will we use tides, wind, sunlight? Kaempffert goes on to consider whether or not the laboratory can create life, the advances of genetics, and Carrel's work in tissue culture. Finally the rapid advances in the physical sciences are discussed and the relation of science to democracy. It is his belief that totalitarianism denies the liberty of mind which is necessary to objective research, and that in science we have the savior of democracy and the nidus of internationalism.

This book is adjusted to the understanding of the general public. Some more critical scientific minds may not rate it highly.



SCIENCE SINCE 1500. *A Short History of Mathematics, Physics, Chemistry, Biology. Board of Education, Science Museum.*

By H. T. Pledge. H. M. Stationery Office, London; British Library of Information, New York. \$2.15. 9½ x 6; 357 + 16 plates; 1939.

This text, a history of mathematics, physics, chemistry, and biology, is a panoramic survey of these sciences from 1500 to recent years. The study is set against a background of human and economic factors in the successive periods. Biography, as a detailed study, has been suppressed, but enough has been given to counterbalance the monotonous effect of the exposition of so many scientific discoveries, theories, and experiments. Particularly interesting is the author's treatment of the microscope in science. Maps showing how the birth-places of scientists seem to cluster about certain geographical locations in particular periods and times and charts showing teacher-pupil relationships for the 16th to 19th centuries form a very interesting piece of work. The latter relationships show how a number of noted scientists fall into a continuous teacher-pupil line; this linkage holds for the experimental and biological sciences rather than for the mathematical—mathe-

maticians seeming to learn from texts, not persons. There are full-page photographs, facsimiles, text drawings, and graphs.



HANDBOOK OF PHOTOGRAPHY.

Edited by Keith Henney and Beverly Dudley. Whittlesey House, McGraw-Hill Book Co., New York and London. \$7.50. 9 x 6; xii + 871; 1939.

The editors of *Photo Technique* have produced a book of great value to the photographer—whether he be specialist or amateur. It comes as near being the photographer's *Vade Mecum* as anything that has so far appeared in print. The 23 contributors (30 sections) have arranged their material in such a way that it is quickly available to the reader. However, it must be said that if the very excellent indexes (author and subject) were lacking this would not be the case, since the subject matter is arranged under topics—with full discussions to make all points clear. Perhaps a *Vade Mecum* is the next stage in development, with this book a valuable and necessary accompaniment. We are unable in the brief space allotted to include a list of the writers but they have been chosen for their outstanding accomplishments in their particular fields. A random sampling of the topics discussed yields the following: optics of photographic lenses, cameras, shutters, photographic sensitometry, photographic light sources, light filters, technique of development, defects in negatives, stereoscopic photography, infrared and ultraviolet photography, color photography, motion picture photography, aerial photography, high-speed photography, photomicrography, and radiography. Tables, graphs, figures and bibliographies enrich the various sections and in a group of appendices additional material not available in the body of the book is arranged.



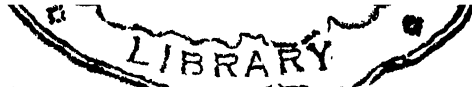
PICTURES WITH A PURPOSE, HOW THEY ARE MADE.

By Charles Kerlee. *Camera Craft Publishing Co., San Francisco.* \$2.50. 10 x 8 $\frac{1}{2}$; 80; 1939 (paper).

This slight volume consists of 24 "pictures with a purpose" or commercial photographs. Each reproduction, and each is very fine of its type, is accompanied by two pages of text in which the author

discusses the particular purpose of the picture in question, the main points to be brought out to accomplish this purpose and the various technicalities employed for best results. This work should be of great interest to amateur photographers who hope to turn their hobby to profit.





THE QUARTERLY REVIEW of BIOLOGY



MAN: A CONSTITUTIONAL INVESTIGATION

By WILLIAM B. TUCKER AND WILLIAM A. LESSA

Departments of Medicine and Anthropology, University of Chicago

I. THE HISTORY OF THOUGHT ON CONSTITUTION

FROM very early written records there is evidence of people believing in some sort of intimate association between the physical make-up of human beings and the various other constituents of their biological patterns.

The Bible and the writings of the Chinese and Hindus indicate that centuries ago men considered that the character of individuals is betrayed by external appearance.

It is not at all surprising, accustomed as one is to the wide range of speculations attributed to him, to find that Aristotle (5) is said to have declared, in his *Physiognomonica*:

There never was an animal with the form of one kind and the mental character of another: the soul and body appropriate to mankind always go together, and this shows that a specific body always involves a specific mental character.

Writing in Latin, Aurelius Cornelius Celsus (51) (53 B.C. - A.D.) advised:

Above all things one should know the nature of constitution, why some persons are slender, others

fat; some are hot, others more cold; some moist, others more dry; why some have tight bowels, others free. Rare is the person who has not some weak part of the body.

Celsus appears to be the first medical writer to observe that physical constitution may be a factor in the etiology of disease.

Important historically is Galen's (95) theory of *Krasis*, for from it arose the notion of temperaments, which will be examined further on.

In the third century A.D. the Greek writer Polemonis (237) continued along Aristotle's lines of observations, and a century later Adamantius (1), a Jewish physician, busied himself with similar observations.

So far little has been said specifically of predisposition to disease. But as early as the fifth century B.C. Hippocrates (129) was writing of a *habitus phthisicus* and a *habitus apoplecticus*; and saying that those who contracted a certain fever were infants, young persons, adults having smooth bodies, white skins, straight and black hair, and dark eyes.

Avicenna (7) (c. 980-1037 A.D.) makes numerous allusions to the im-

portance of taking "temperament" into consideration in the study of character and in defining certain functions in an individual. But, like Hippocrates and Galen, he does not particularly correlate form with disease.

Immediately after the Renaissance in Italy there came about a revival of science. At that time the Neapolitan philosopher Giambattista della Porta (66) (1536-1615), influenced by Aristotle, Ptolemonis, and Adamantius, made correlations between facial characteristics and moral and intellectual traits. This scholar was also somewhat of a caricature artist, and it is interesting to examine his drawings illustrating the parallels between men with certain qualities and the animals regarded as the prototypes of these specific qualities.

Of historical interest to anthropologists is the fact that in 1654 Johannis Sigismundi Elsholzius (77) had established a method of taking measurements of the body and had for the first time employed the word *anthropometria*. It is of further interest to note, in this connection, that Quetelet (239), great Belgian mathematician and astronomer (1796-1874), in 1871 was the first to study measurements of man statistically, using chiefly the figures of artists as the only appreciable source up until that time; and he thought he invented the word *anthropometrie*, unaware apparently that Elsholzius had employed it over two hundred years previously.

One of the first to attempt to correlate constitution with psychiatric disease was Walkington (321). In his *Optick Glasse of Humors* (1663), he expresses his opinions on the relation between function and form as revealed by a physiognomical analysis.

John Hunter (137) (1728-1793) was unusually scientific in his attitude toward

the various aspects of constitution. He believed that the symptoms of a disease were the result of the interaction between certain constitutions and pathologic forces. Within the individual himself, said Hunter, certain systems may show a greater susceptibility to disease than others:

Thus as the liver in some constitutions is more susceptible to secreting bile, which is its natural action, than it is in others, so also it is more susceptible of its peculiar diseases in some constitutions than it is in others. (p. 304.)

He also said that susceptibility to disease varied with constitutions:

For example, some constitutions are more susceptible of inflammatory fevers than any other fevers; others are more susceptible to putrid fevers; while either one or the other of these constitutions might have some other disease, either violently or mildly, as smallpox, measles, etc. (p. 303.)

Hunter recognized how complex is the nature of constitution, and how varied were its applications to the study of disease.

One man is especially interesting for his curious conception that since whatever is beautiful and harmonious is holy and good, then all men with good historical reputation had in full the physical characteristics associated with valor, virtue, etc. Lavater (168) was a Swiss—a Protestant minister. His writings were often unintentionally humorous.

At about this time phrenology began to receive serious consideration. Two reputable anatomists, F. J. Gall (96) (1757-1828) and J. C. Spurzheim (283) (1776-1832), fell into the error of believing that mental traits could be read by means of the shape of the head, because various qualities were localized within it. Their work was especially discredited by the adoption of their observational techniques by a rising profusion of phrenological charlatans. Phrenology was but one of

two branches of constitutional somatology to endeavor to connect intellectual capacity, talents, and disposition with morphology.

Criminal anthropology also concerned itself with such related problems. Cesare Lombroso (178), whose name is still revered and respected by many, discovered that in criminals there are to be found certain anatomic "abnormalities" or "stigmata," which are, he said, normally found in lower animals. Therefore, reasoned Lombroso, criminals with these marks are a throwback in the evolutionary scale, and criminality in certain of its forms is an atavistic trait. Though Goring (106) and Perrier (129) exposed certain weaknesses in the argument, the theory has never been entirely discredited. The recent work of Professor Hooton (134) of Harvard, while not in the least subscribing to the Lombrosian doctrine of atavism, was largely inspired by the still-present interest in the subject. (See section V.D. 1.)

Simultaneous with the physiognomic stress given to the study of the body-build was the theory of temperaments. The famous physicians of the Graeco-Roman period left as their chief heritage a fourfold classification of constitutional types. Influenced by Empedocles' and Pythagoras' four primary elements (fire, water, earth and air), they spoke of four "humors"—blood, lymph, black bile and yellow bile—which by their state of balance decided health and disease. The individual's anatomical, physiological, and mental characteristics reflected the dominance of one of the humors, and Hippocrates (129) and Galen (95) and their disciples down through the centuries believed that in order to diagnose and treat disease it was necessary to ascertain the patient's temperament in terms of such humors.

The humoral theory has never been completely discarded, and today persists in altered form, particularly in some of the medical thought on human constitution. In the middle of the nineteenth century Thomas Laycock (169) of the University of Edinburgh used a sevenfold classification not very different from the ancient one.

Jean Esquirol (83) (1772-1840), the French alienist, was influenced by the post-Galenic descriptions of temperaments. He observed that when persons of the lymphatic or phlegmatic temperament fall into mania or monomania they tend to a chronic and deranging course of the disease, whereas those of sanguine, strong and robust temperament tend more to the acute course of the psychosis. Esquirol's classification, though hardly scientific, anticipates in a way the modern distinction between manic-depressive types with a more acute course, and schizophrenic types with more chronic and degenerative courses.

With the opening of the nineteenth century came an awakened interest in many phases of constitution, and the great English clinicians of the time made valuable contributions. Though the foremost student of the problem was Jonathan Hutchinson (138), Feigenbaum and Howat (87) point out that it is wrong to suppose he had faith in the relationship between constitution and diseases, for Hutchinson said the student of constitution

... will discover he is mistaking for criteria of temperament conditions which are simply indicative of youth, or age, or health or disease, or the effects of past anxiety or trouble ... so should the student of temperament scrupulously reject all that has been superadded and is in a sense accidental. ... Indeed it may be questioned whether in a large majority of cases there usually exists in persons as yet in perfect health any peculiarity by which we can predicate or discriminate the "fundamental mode of vital activity" (constitution).

The study of constitution was neglected for many years after Pasteur's researches on bacteria and many other bacteriological and pathological advances of the latter half of the nineteenth century had rolled up an immense enthusiasm for the study of the exogenous factors of disease. In Europe, particularly in Germany, Austria, Italy, and France, where the tradition of the endogenous—constitutional—factors lived in many of the older physicians and scientists, the newer interest in exogenous factors never entirely displaced the constitutional approach to biological problems. In the United States, however, with modern medical schools developing only since the time of Pasteur, the absence of the older constitutional tradition has been felt and evidenced in the almost entire absence of a consideration of constitution in medicine. This state of affairs has persisted up until very recent years.

The contemporary phase of constitutional studies may perhaps be attributed to the interest of di Giovanni (68); but to understand his background it is necessary to know that he derived his inspiration from Beneke, a German pathological anatomist, who in 1878 and 1881 expressed a new viewpoint in constitutional studies. For, whereas through the years many had made observations on the exterior of the body, Beneke was the first to measure the internal organs and their variations in size, as associated with age, disease, and body type. However, we must not forget that as far back as 1632 Spigelius (282) had described a ratio between intestinal length and body length; and in 1764 de Haën (65) had tried to relate the variations in position of internal organs to disease. Beneke (26, 27, 28, 29) ascertained two somatic types, the scrofulous-phthisical constitution, which may be compared with the asthenic type in more recent terminology, and a

second type, comparable to the more recent pyknic, which Beneke believed to be associated with rachitism in children and cancer in adults.

The concept of type among humans has fallen into serious disrepute in recent years, particularly as the result of biometric analyses which fail to show multimodal distributions of human characters, which can be the only logical basis for clear recognition of types. Among the older authors, like Beneke, just what is meant by "type" is not quite clear, but it seems to refer to an aggregation of individuals around some special criterion, as linearity, robusticity, or solidity. Speaking statistically, it may be permissible to consider a type as one of several individuals at or near an extreme of any biological variation with respect to some especial quality—e.g., beyond 1.5, or 2, or 3 standard deviations from the mean in either direction. Obviously if different criteria or combinations of criteria are used for examining the same population, there may be a large number of types. In this sense, a "type" as an "extreme"—a deviate of statistical significance from the mean—is entirely different and quite distinct from an "average" or "normal," which latter terms connote non-significant deviation from the mean.

Di Giovanni (68) was the only one to take serious notice of Beneke's work, and listed other diseases associated with the two types. He also stated that the cause of the special morbidity of an organ system resides in its disproportionate development relative to other organs. In evaluating di Giovanni's work, we note two important contributions: first, that he observed the apparent changes in habitus and consequently of morbidity that are due to age, and advocated that body growth be constantly observed; and, second, that he was responsible for more exact methods of determining body build, employing for this purpose the techniques of anthropometry. Two other Italians, Viola and Pende, carried on di Giovanni's work and have helped form one of the most important schools of constitutional thought and research existing today.

SUMMARY

Thus we note an extremely early interest in the relationship between the body of man and other characteristics of his constitution, and a gradual evolution, in increasingly sharper focus, of the understanding of these problems. And it would seem that scientific thought of earlier periods has been seriously affected by the extensive advances made in the last 80-90 years in the fields of bacteriology, histology, physiology, biochemistry, and allied branches of biological science.

It is important to recognize that the bulk of this scientific investigation has been directed at a study of the environmental influence affecting man, or of the effect of such environmental factors upon man, rather than at the importantly different matter of the manner in which man's constitution affects and reacts upon environment, in determining his own behavior. One shrewd observer (134, p. 394) has noted, for example, that the medical profession "faced for centuries with the most blatantly obvious structural-functional relations, . . . has . . . turned away and occupied itself exclusively with diseases, microorganisms, pharmacology, hygiene, immunology, and everything except man itself." In short, it seems permissible to state that in the scientific advances of the last century the study of man's constitution has been, if not completely lost sight of, at least thrust temporarily into the background by a much-needed investigation of man's environment as it affects and influences his behavior.

Deeply impressed with the significance of constitutional knowledge, Viola (310, p. 1634) considers the beginning of scientific work in this field to be one of the milestones in medical history, comparing it with the advances inaugurated by the

work of Mondino, Harvey, Malpighi, and Pasteur.

It will be well now to consider more thoroughly the exact nature of man's constitution.

II. THE NATURE OF CONSTITUTION

A. *Preliminary definition of constitution*

For the purposes of introducing a consideration of the nature of constitution, it will be defined as *the total biological make-up of an individual*. Several aspects of constitution and some of the conflicting theories on this subject will be considered. Though the term constitution may obviously cover a vast field, one cannot be immediately concerned with all possible ramifications, such as a detailed consideration of the relationships between body-build and crime, temperament, and intelligence. These will be dealt with briefly in a later section.

B. *Constitution a multi-sided problem*

It is obvious that the problem of constitution is a multi-sided one. In fact it has so many aspects that many writers have quailed at the prospect of considering it *in toto* and have fractionated it in varying degrees.

Yet it is important constantly to maintain a perspective and to keep in mind the fundamental unity of the biological organism that is man, even when admitting the necessity of dividing the problem as a whole into a number of aspects in order to study it more objectively.

Many authors have considered only comparatively minor aspects of constitution, such as variations in morphology, including relatively small parts of the body, as the ear (Vollmer, 311 and Bean, 21), the scapula (Graves, 109), etc.; or they have limited their observations to the more important, but still incom-

plete, consideration of the relationships of body build to disease, as will be seen later in this paper. Medical writers in particular have been prone to use the word constitution rather loosely, as in speaking of constitutional disposition, constitutional effect, etc. (e.g., Mazer, Mcranze, and Israel (194) speak of the "constitutional effects" of large doses of estrogenic principle) without making clear the meaning of this term.

The further tremendous diversity of biological variables that may be considered under the general heading of constitution is well illustrated by the following brief samples of investigations in this field: Strina (196) considers the question of the possible existence of a special somatic type among unmarried mothers; Lorentz (179) discusses indices and a "new constitutional formula" in the study of athletes in the 1936 Olympic games; Amano (4) considers the influence of climate on the human body with special reference to baseball matches; Houghton (135) finds it worth while to consider certain constitutional patterns as hazards of anesthesia; Bartels (12) takes up the question of gymnastics and a dietary regime for pyknics. The profusion of studies on this subject, in its less, as well as its more clearly defined aspects, is best illustrated by the fact that in the last five years of the *Cumulative Quarterly Index Medicus* over 1000 titles are listed under the heading Constitution; and Julius Bauer has from time to time listed the constitutional bibliography with additional hundreds of titles (e.g., 17, 18).

Amid this welter of divergent thought it is necessary to make some division of the field of constitution into logical subdivisions that are at once at least partially discrete, susceptible of correlational study and reasonably conformant to the present

state of our knowledge of man. Fortunately there is among the more serious students of this field some considerable agreement as to the form which such a sub-division should take. Even the ancients, as has been seen above, distinguished between form and behavior, psychological or "humoral." Barbára (9) noted that the classifications of the Italian school in a measure restored the four-fold classification of Hippocratic medicine and in modern terms its humoral basis. Pende (228), student of Viola, finds it convenient to employ a "semiological analysis" of constitution according to three "criteria," all springing from an hereditary base—the morphological, the dynamic-humoral (neuro-chemical), and the psychological—to unite, like the faces of a three-sided pyramid, in an apex of the total development and integration of the personality.

Brandt (40), in addition to a consideration of the rôle of heredity in constitution, studies the morphology, the physiology, including growth and differentiation, and the psychology of individuals. Draper considers the study of human constitution to fall naturally into four "panels of personality," in which one may investigate "the hereditary unit characters found in the domains of anatomy, physiology, psychology, and immunity" (69, p. 25). It is not quite clear why Draper separates immunological factors from other physiological characters. Pearl and Ciocco (221, p. 650) in studying human constitution consider the integrated biological relations "between the morphological, physiological, psychological, and pathological characteristics of the individual." Miller (197) uses a trichotomy of morphological, physiological and psychological aspects. This seems to be the commonest mode of dividing the field of constitution into a number of different

aspects. Insofar as pathology (or anomaly) may be considered an "abnormally" extreme deviation of biological characters varying "normally," however, the physiological and pathological aspects of constitution may well be considered as one single phase of the subject, and the total number reduced to three—the morphological, the physio-pathological, and the psychological—agreeing roughly with Pende's divisions. It is, of course, necessary to recognize that such separations are purely arbitrary. It is almost impossible in the final analysis to distinguish morphology from function. Psychological aspects of the personality may only arbitrarily be separated from other physiological properties of the individual's nervous system. And pathology may be an abnormal deviation in any of the three aspects, morphology (anomaly), physiology (disease), or psychology (psychosis or psychoneurosis). Because the major emphasis in pathology still remains in the field of medicine, however, it seems justifiable to allocate this aspect of constitutional variation primarily to the physiological face of Pende's pyramid.

Finally, in a discussion of the aspects of constitution, it is well again to emphasize the essential unitary pattern of the individual. In the study of the relation of constitution and disease in man many authors have emphasized the necessity of treating man as a whole. Typical are the opinions of Rippey (244), Benedetti (23, 24), and Hnat (131). Pearl and Ciocco (221, p. 650) state that the study of constitution has for one of its major objectives a study of the "integrated biological relations" between the various characteristics of the individual. Hooton reflects the same philosophy when he says (132, p. 6), after mentioning physiology and psychology as well as various morphological relationships:

"They are merely bound together in an indissoluble organic association, such that one may be predicted, to some extent, from the other." And Draper is a particularly able advocate of the unitary approach to man in a consideration of any aspect of his constitution (72, 73). In his plea for the constitutional approach to an individual as a "complete organism," he uses a meaningful phrase, to denote man a "complete psychosomatic being" (73).

It will be useful, from this perspective, —that of the multi-sided problem of an individual's constitution, springing from an hereditary base, with morphology, physiology, and psychology, all influenced to some extent by environment, as arbitrarily but usefully differentiated aspects of an individual's total personality—to study further some of the concepts of various authors which exhibit conflicting theories as to the nature of constitution, particularly as to the relative rôles of heredity and environment. From an evaluation of these concepts it may be possible more exactly to define constitution.

C. Conflicting theories regarding the nature of constitution

It is not entirely clear if a definition of constitution should include only inherited tendencies, that is, those characteristics present in the germ plasm at the time of conception. The emphasis of the so-called genetic school of constitutionalists has been almost wholly on heredity. Beginning with Martius, one sees that it is the genotype which determines constitution, not environmental influences. According to Martius (190-191), constitution is "... the somatic aggregate (inclusive of irritability and liability to disease) that remains the relatively unaltered possession of the individual, with the

characteristic reactivity of the organism more or less permanently fixed." Tandler (298) and Julius Bauer (13, 14, 16) make a similar limitation and keep the term *condition* for the make-up as it exists from the action of external forces. Actually, such a distinction is not easy or even possible.

For this reason most authors have decided that in settling this problem of the determining factors of different diseases, it is necessary to consider the effect of environmental influence. Chaillou and MacAuliffe (52), students of Sigaud, stressed the environmental factor in their four-fold classification of man, believing that the four points at which he had chief contact with his environment—respiratory, digestive, muscular, cerebral—had much to do with the way the soma developed one of these organ systems more predominantly than the others, as a sign of resistance to a particular type of unfavorable environment, including disease. Petersen (230) points out that at least from the medical point of view constitution cannot remain static and the term must embrace not only the quality of the protoplasm in its form and structure, but also the functional status as made apparent in physiological and pathological reactivity; in adaptability to change in environment; in modifications produced by season, climate, diet, age, endogenous and exogenous irritants, disease, physical and mental trauma, and the ever varying forces of the universe of which the individual is a part.

Borchardt (37, 38) does not think it possible to divide constitutional anomalies into hereditary and acquired. He also disagrees with the distinction between constitution and condition, saying the former cannot have a heredo-biological foundation alone. So he defines it as

... the status of the individual as conditioned by heredity and environment; it is the totality of the

individual, in structure, form, appearance, physical and psychological ability, reactivity, the condition of the nutrition, the resistance to infections and intoxications, the psychic make-up irrespective of the contingency of the individual phenomena or heredity of environmental influences.

Similarly, Draper (71) says that the term constitution "... should connote that aggregate of hereditary characters, influenced more or less by environment, which determines the individual's reaction, successful or unsuccessful to the stress of environment." He hastens to point out how difficult it is to say which of the so-called inherited values are true germ plasm transmissions, as for example, eye color, and which are habit or imitative characters, such as certain family tricks of gait or gesture. Brugsch (42) says that

Constitution is the unity of the physico-chemical elements which make up a definite definable system whose coordinating internal forces establish ... a balance with the external forces whereby the internal forces are laid down in the genes but the final stamp is placed on the constitution by reactivity to environment.

Walter Freeman (92) gives the following definition: "The constitution of an individual may be defined as the sum-total of all his peculiarities and potentialities. Just how much is a matter of genes and how much is conditioned by early environment cannot be determined accurately." (p. 805.) And Feigenbaum and Howat (87) state: "Constitution may be defined as the sum total of native or acquired characters by virtue of which the individual is rendered more or less susceptible to disease. ..." They point out, in addition, certain practical difficulties in evaluating the constitution: (1) One must be reasonably sure that certain body proportions are not *caused* by the disease. For this reason they avoided selecting diseases which are characterized especially by cachexia, and also chose as measuring points certain skeletal points not likely to be affected by the disease except in

unusual cases. (2) The racial factor is an important one. And (3) discrepancies in results will appear because of statistical differences in selection of material, unless great care is taken to equate such factors.

SUMMARY

From these samples, it would seem to be the consensus of authoritative opinion that constitution in its many-sided aspects is not to be thought of, in its narrowest sense, as strictly or even predominantly a hereditary characteristic of the body, as the hereditary school of constitutionalists would insist, but as expressing the sum total of biological characteristics, both genotypic and phenotypic.

It will be appropriate to examine further in some detail the rôle of heredity in determining the various aspects of constitutional behavior.

D. The inheritance of constitutional factors

The nature of gene dominance and recessiveness in man is not clearly determined, and our knowledge varies with various details of the constitution.

1. The inheritance of morphological characters

Morphological characteristics, such as eye color and hair color, are more readily studied with their relation to heredity than physiological and other constitutional characteristics. If heredity were the sole determinant of type, then the problem of racial classification would be solved, but while it is accepted that genetic factors operate in determining the constitutional aspects of the body, it is known that the genes concerned are so numerous and environmental factors so important, that inheritance of racial type can be spoken of only in a broad sense. It is more profitable to deal with the hereditary basis of bodily proportions of one individual as compared with another,

for with few exceptions, which are the result of selective processes, there are no bodily forms typical of any race.

Most of the work in the inheritance of physical traits in man has been done by anthropologists. Their method has been to utilize racial hybridization. The results of such studies are very informative, for there seems to be no reason why their findings may not be applied to inheritance *within* racial groupings. Krogman (161) has gathered data on the heritability of non-pathological traits in man, the groups studied by the several investigators whose material he utilizes being mostly White-Indian, White-Negro, and White-Asiatic. He says:

In general man is subservient to genetic rules. Physical traits tend to act as unit characters. In a cross there may occur a phenotypic blend, but genotypic modifications occur rarely as mutations. . . . The environment plays a definite rôle. The genetic constitution does not change, but its expression may vary, the optimum may or may not be achieved.

Krogman divides features into three categories, depending on their value for analysis of race or group physical traits.

It is obvious that in assessing heritability of constitutional types such definite principles of analysis cannot be followed, for though there is undoubtedly a racial factor to be considered in establishing types many of the features of physique are non-racial. It is possible, however, to utilize the anthropologists' knowledge of physical inheritance.

Study of the Dionne quintuplets has afforded interesting data regarding the inheritance of behavior, personality, and temperament. Blatz (33) says that despite the fact that all five carry exactly the same types of whatever genes there are for behavior, personality and temperament, the girls show even greater variations in these characters than in physical make-up and mentality. This would seem to indicate that environment must be

considered as a constantly operating factor. Newman's (213) study of identical twins causes him to conclude that they show marked similarities in behavior and personality which cannot be entirely explained on the ground of similar environment; that physical characters are affected least by environment; intelligence more; education and achievement still more; and personality and temperament most.

Ritala (245), using a different approach, has studied the inheritance of body measurements in new-born children, and has found some definite correlations.

Thus even in a consideration of man's body, his most fixed character, it will be seen that it is difficult if not impossible to distinguish between strictly hereditary and strictly environmental factors. That even the factor of nutrition as it affects morphology may not be primarily an environmental one is suggested by Montessori (203, pp. 75-76), who finds that the broad, lateral, or stocky individual has a larger volume of digestive organs as related to his total body mass than does the slender, linear individual. She suggests that this may be an hereditary factor influencing physical status in addition to the strictly environmental one of the amount of food ingested. Montessori has characterized the linear individual as having a small boiler and a relatively large engine, and the lateral individual as having a large boiler with a smaller engine! However, objective facts are not completely available as yet to support this thesis, and Draper (71) finds this part of the morphological problem much more complex than Montessori's presentation would indicate. Studies relating internal organs to external dimensions have also been contributed by Bean (20), Castaldi (50), Rössle and Roulet (250), students

of Castaldi, and by Pearl, Gooch, and Freeman (222), among others.

It is apparent that human morphology or body-build is probably in large part fixed by heredity and to some small extent influenced by environmental factors. Davenport (63), in a study of inheritance in body build, believes that the stronger of these two elements influencing morphology is one of pure gene heredity. He seems convinced that he has been able to prove satisfactorily that such morphological characters as height and body build in general are the expression of two or three, or in a few instances as many as four, determiners of heredity; and that there may even be more hereditary determiners influencing morphology through the indirect means of physiological variation; and that environmental factors play a relatively minor rôle in the determination of human morphology.

An extremely important consideration in this connection is the constancy of the body build. This will be discussed in some detail in a later section, under the discussion of age as a factor in constitution (see section II. E. 3.).

2. The inheritance of physiological characters

If there was difficulty in establishing the influence of heredity as distinguished from environment in the determination of morphological characters, it is obvious that the problem is infinitely more complex in the case of the study of inheritance of physiological characters. Little enough is known of inheritance in man anyway. Petersen (230) in commenting on this problem says: "The human is a poor animal for genetic study; the interval between generations is too long, the control of the characteristics bred utterly impossible." The closest approximation

in man to the laboratory methods of observation of the operation of hereditary factors in animals is in the study of physiological processes in identical twins, and it is fortunate that a number of careful studies have been made in this field, not only with regard to physiological processes but also with respect to disease propensities (see section II. D. 4.).

In Germany, for example, Lenz (172), Siemens (276), von Verschuer (318, 319), and Weitz (325) studied respiratory rhythm, blood pressure responses, and characteristic pulse frequencies, and felt that they found sufficient evidence to establish the strong likelihood of the heritability of these characters. Curtius (60) and Curtius and Korkhaus (61) in identical twins found marked similarities in response to such physiological tests as injections of epinephrine and the Volhard test (the determination of urine secretion and of the hemoglobin after taking a certain amount of water on an empty stomach), the latter test in many cases exhibiting an absolute concordance in the two twins. Geyer (101) in general confirms these observations. Curtius and Korkhaus (61) in one pair of identical twins even found identical extra systoles, suggesting that perhaps identical stimuli affected the vagi as well as the heart ganglia in an identical manner in the two individuals, thus indicating the probable hereditary influence of such physiologic regulation. They likewise observed other similarities in physiological phenomena, as similar or identical pigment distribution and vascularization of the skin.

K. H. Bauer (19) in cross-grafting skin from one identical twin to the other noted the "humoral identity" of the skin of such twins. According to Petersen (230), Westergreen studied the sedimentation rate in unioval twins and found marked

parallelisms. On the other hand, Bernheim-Karrer (30) studied the bactericidal property of the serum of identical twins and found decided differences, so it is clear that not all physiological properties of identical twins are necessarily similar.

Another interesting approach to this problem of the inheritance of physiological characters has been made by E. Fischer (90) who studied Boer-Hottentot bastard crossings and noted many apparently significant differences in the behavior of the resultant filial generations.

In the field of physiology the inheritance of blood group types is one of the clearest demonstrations of Mendelian gene inheritance. Within recent years the genetics of new and independent antigens has been satisfactorily determined. In 1910 von Dungern and Hirschfeld (313) held A and B to be dominant, and O recessive. Bernstein (31) showed in 1924 that there are six genotypes and four phenotypes, and this number was increased to ten and six respectively when a "strong" and a "weak" A were found by Thomsen, Friedenreich, and Worsaae (300).

An important advance occurred two years later when Landsteiner and Levine (167) postulated two new and independent antigens, M and N, resulting in two systems, ABO, and MN, which give eighteen classes of blood. Each of the six ABO blood groups is divided into three classes according to the presence of M, N, or MN.

The matter has been further complicated by Friedenreich's (94) demonstration of an N_2 , recessive to the ordinary N gene (now N_1), and an A_3 , dominant to O (as are A_1 and A_2) but recessive to A_1 and A_2 . The complete ABO system now has fifteen genotypes and eight phenotypes.

Though the evidence is far from conclusive, there is good reason to believe that heredity determines physiological be-

havior as well as morphology, to a very large extent, even though environment may play an appreciable rôle.

3. The inheritance of psychological characters

It is harder to speak with assurance regarding the inheritance of psychological types and patterns. There is a growing belief that they are to a large extent predetermined by heredity, though environment surely plays a relatively large part. Nathaniel Hirsch (130), on the basis of a study of over one hundred similar and dissimilar twins, concludes that though both heredity and environment contribute to the development of intelligence in humans, their contributions are far from being equal, heredity being about five times as significant as environment in determining I.Q. differences between twins.

According to the studies of Seashore (264-268), the various senses required for musical aptitude have a constitutional basis. A genetic study of musical talent by Scheinfeld (259) causes him to conclude that "musical talent is in all probability inherited through a number of genes acting together, and without the required genes there can be no musical talent" (p. 271). But he does not dismiss or neglect the influence of environment, which he believes cannot create talent but may suppress or "veto" it.

Summing up the prevalent beliefs of psychologists regarding the various factors involved in producing personality, Scheinfeld (259, pp. 298, 299) says that the likelihoods of their being produced by heredity are:

Most likely to be influenced by heredity: Basic abilities, such as intelligence, speed of reaction, motor skills, sensory discrimination, etc.

Less likely to be influenced by heredity: Temperamental traits, such as emotionality, alternation or

evenness of mood, activity or lethargy, and other characteristics in which gland activity is conceivably involved.

Least likely to be influenced by heredity:—(if at all)—Attitudes, stylistic traits, beliefs, values, and other such characteristics in which training or conditioning are clearly major factors.

4. Heredity in relation to the etiology of disease

Of more interest perhaps to many is the question similar to those asked of the rôle of heredity in morphology, physiology, and psychology: what is the relative importance of heredity in the predisposition to disease?

All disease may be defined as simply an "abnormal" or "pathological" variation of biological processes ordinarily varying "normally," in an individual or in a group of individuals. A recognizable disease entity obviously is not a simple biological matter, and is the result of variations in a number of related biological processes. Yet there is scarcely a biological picture to be recognized as pathological—i.e. a disease—which does not have at sub-clinical levels its closely approximated counterpart, different only in degree of abnormality—i.e. deviation from the mean behavior. This is true in practically every field of biological pathology, whether morphological, physiological, or psychological. In the field of medicine many examples could be given; here it is necessary to mention only one: the work of Konjetzny in the field of carcinoma of the stomach. Konjetzny (153, 154), studying chronic hypertrophic gastritis as a possible precancerous condition, finds in some stomachs situations where it is quite impossible to define the borderline between a benign and a malignant condition, and concludes that the entity malignancy, under such circumstances, is unquestionably a relative matter. The same may even be said of many

infectious diseases, as tuberculosis, pneumonia, influenza; of degenerative diseases, as of the cardio-vascular-renal system; and even of traumatic accidents and other acute surgical conditions: in essentially any kind of pathological variation, there is an ill-defined zone between normality and abnormality, between health and disease.

If this concept of disease be tentatively accepted, the basic problem can then be stated: What is the rôle of the hereditary aspect of constitution in the occurrence of these extreme degrees of biological variation—i.e. in the etiology of disease; and the allied problem, how can a consideration of these matters aid in a better understanding of the nature of constitution? In the constitutional consideration of pathology and disease there are many aspects subservient to the rôle of heredity's contribution to the etiology of disease. Some of these will be discussed in a later section (see section V. C.). Here will be considered briefly the rôle of heredity in predisposition to disease.

The same difficulties encountered in studying the relationship between heredity and physiology naturally are evident here. But enough valid observations have been made to permit Borchardt (37) to list a considerable number of pathological conditions as they seem, according to various workers, to have definite hereditary constitutional factors in their etiology, dependent on dominant, recessive, or sex-linked recessive hereditary characters.

In various diseases heredity naturally plays a varying rôle. Hemophilia perhaps is the best illustration in man of a disease with a sex-linked inheritance. Otosclerosis seems proven to be dependent on a strong endogenous (hereditary) factor. Häcker (118, 119) believes that, on the basis of the family history, diseases

may be grouped in one of two categories: (a) "associated with Mendelian transmission," or (b) an "inherited . . . constitution or a certain habitus or status—a soil on which varying pathological conditions may develop, depending on conditions."

In addition to such diseases as those in which the hereditary element plays a proportionately large or even determining rôle, there are many diseases which are relatively impartial in their selection of victims. These in man are chiefly the infectious diseases, where the environmental factors—encounters with bacteria—are largely determinant. There are other pathological conditions in which disease seems to be due more largely to such fortuitous, not innate, determinants as nutrition, poisons, irritants, physical accidents, psychic influences, and the loss of acquired immunity. But even in the face of such circumstances it is necessary to remember that individuals vary widely in the form and severity of their reaction to their exposure to approximately equal amounts of such non-hereditary forces. Thus it is suggested that even in such conditions the hereditary constitutional element is at least partly a determinant of the course of the disease. Further discussion of the relation between constitution in general and disease will be deferred to a later section.

In between the extremes of pathological conditions determined predominantly by heredity or by environment, and ignoring those diseases in which the etiology is unknown, must be recognized a third and intermediate class, for it is not possible to place many pathological conditions at or near either of these extremes. In this middle group are to be found those diseases in which the determinants are largely but not wholly both endogenous and exogenous: diseases of the glands of

internal secretion and of the autonomic nervous system, both sympathetic and parasympathetic.

It will be well here to recall that health or disease is essentially the result of a state of balance or imbalance among a great number of biological variables, both hereditary and environmental; morphological, physiological, psychological; all also expressed as a function in time, or of the age of the individual. Pearl (220) has defined this difficult picture well, while discussing the relationship between constitution and health:

The biological constitution (total personality) of an individual at a given moment depends directly and immediately upon and is determined by, at least, A—The present functional condition (tonus and balance) and state of activity of the endocrine system, the autonomic nervous system, the vascular and vasomotor system, and the central nervous system (psychic influence). All of which in turn depend in part upon B, the physical chemistry of the blood, and the innate degree of perfection (biological worth) of the anatomical structure in general, and of each particular organ, and the age of the individual.

He summarizes by saying that all of these biologically integrated variables derive from "the inherited kind and quality of the biological organization and from the environmental circumstances and forces, past and present." These two factors are usually called the *genotype*,—a term used by Johannsen (142) as referring to the "inherited germ plasm," also called "idiotype" by Siemens (276)—and the *paratype*. In this country geneticists employ the term *phenotype* to denote the individual resulting from the reactions between the genotype (the purely germinal make-up) and the environment (287). Naegeli (209, 210) has made a very thorough study of the genotypic factor in the heredity of many medical entities, and lists a number of interesting genetic mutations.

A useful approach to the study of the

rôle of the genotypic factor in disease, as was the case with the relationship of heredity to physiological processes, is to observe disease reactions in identical twins, although even this closest approximation in humans to laboratory conditions leaves much to be desired, and has not been very extensively employed. Siemens (276) cites examples of striking similarities of pathological reactivity in identical twins. Ganther and Rominger (97) have found similar manifestations of exudative diathesis in unioval pairs of twins. Petersen and Levinson (231) studied a pair of such twins infected with tuberculosis, and found that both had been infected in early childhood, that activation of the disease commenced in both between the eighteenth and nineteenth years, and that the clinical findings and courses were identical. And Curtius and Korkhaus (61) found a marked parallelism in the clinical phenomena of tuberculosis in a pair of identical twins, including similar localization of fibrosis, similar tuberculin reactions, and other parallelisms in the lungs and lymph glands. But other observers have not observed similar concordance of tuberculosis in identical twins, so this evidence is not conclusive.

Much work has been done in studying heredity with regard to cancer, both in experimental animals and in man. Loeb (177) and Slye (278) are among those well known for their work in this field. Petersen (230, p. 305), commenting on the problem of heredity in cancer, says: "We presumably deal with two factors, a disposition to blastoma formation on one hand and inheritable resistance on the other. But exogenous elements frequently enter into the initiation of the process." While much is known of the rôle of heredity in cancer in animals, where it is possible to control gene factors to some

extent through careful breeding, it is dangerous to draw close parallels in applying such knowledge to humans. Little (174) in a recent publication states in this connection: "Life superimposes so many varying circumstances and facts that any hereditary tendency so far detected may easily become swamped by other influences. . . . The risk of having cancer because one or both parents had it is not of practical importance."

Perhaps no single infectious disease has been studied quite so extensively in man, with regard to hereditary as well as other constitutional aspects, as pulmonary tuberculosis. This is not to say that conclusive evidence is available to support one hypothesis or another on this subject. Pearson (227) introduced the correlational statistical technique as early as 1912 in an effort to obtain direct evidence as to the rôle of inheritance in a tuberculous diathesis, and believed that the results he obtained were positive, though others have been doubtful. Drolet (76) in 1924 and 1925 maintained that children of tuberculous parents do not inherit a disposition to tuberculous disease but instead exhibit an increasing degree of immunity against it. Gottstein (107) has also made a statistical study of the influence of heredity in tuberculosis. Grimes (113) in an exceedingly interesting study of *The Natural History of Phthisis* in rural Iowa families in 1931 found a *factor besides infection*, presumably identified as heredity, which played the major rôle in the disposition to the disease, though he recognized the importance of immunity, both natural and acquired. Alons (3) and Münter (205) by painstaking studies of tuberculosis in families have tended to support the hereditary hypothesis.

From the experimental biological standpoint comes some interesting further evidence in favor of a considerable hered-

itary factor in the predisposition to tuberculosis. Lewis and Wright (173) state:

Using guinea-pigs belonging to families subjected to continuous inbreeding until they are homozygous in the hereditary sense, and subsequent crosses between these strains, it has been definitely shown that resistance to tuberculosis depends in part on factors which are hereditary. The essential independence of these factors of other factors governing color, fertility, and general vigor is indicated. Resistance to experimental tuberculosis in guinea-pigs is much more under the influence of these inherited but undetermined factors than it is under that of certain other factors also concerned, such as sex, age, weight, etc.

Pearl (218) has made a careful statistical evaluation of the relative effects of heredity and environment in the development of clinical pulmonary tuberculosis in man. He was successful in employing biometric techniques to distinguish between the relative importance of contact (environment) in families in which tuberculosis existed, and heredity *and* contact—by studying members of households not members of families but in as intimate contact—and thus indirectly was able to distinguish between genotypic and phenotypic factors. He concludes that the hereditary factor is the more important one.

Petersen (230, pp. 304-305), in reviewing much of this evidence for and against the influence of heredity in tuberculosis, says: "Constitution, both genotypic and paratypic, may therefore even be the determining factor in an infectious disease such as tuberculosis."

These considerations as to the rôle of heredity in tuberculosis, to a certain extent typical of similar considerations in all disease, lead to the conclusion that pathology, or disease, in all cases to some degree and in some cases to a high degree, is influenced by heredity as a predetermining factor; and that in this sense an individual when conceived is, within

limits probably statistically definable, likely not only to be of a certain form and shape and to behave in a certain physiological and psychological manner, but also will be likely to deviate from a "normal" behavior pattern in a predictably "abnormal" or "pathological" pattern.

E. Other factors in the determination of constitution

Thus far, in considering the nature of constitution, we have recognized the multi-sided aspect of the problem, involving at least morphology, physiology and psychology, and have included a brief introduction to the concept of resistance to disease. We have further recognized the rôle, in a different dimension, of the factors of heredity and environment. And we have sought to emphasize the essential unity of the constitutional picture. It is clear, however, that these factors already mentioned do not complete the list of variables involved in a consideration of constitution. Closely allied with the hereditary aspects of the problem are the further (partially dependent) variables of race and sex. A further variable to be considered is the variable in time—age. A brief consideration of each of these will enable us more completely to define constitution, and will serve more adequately to introduce the methodology of the study of constitution and a résumé of some of the more important findings made by various workers in the various aspects of the constitutional problem.

1. The race factor in constitution

Is racial distribution a causal factor for the morphological types which have been established by the constitutionalists? Hooton (132, pp. 476-481) says that in his opinion " 'constitutional' types have

little racial significance; they are individual types or at most family types." Nevertheless his data show that there are morphological characteristics in races which vary somewhat as do constitutional characters.

Under the "lateral" type he lists several Mongoloid peoples, the Eskimo of the Northwest Coast, the American Indians of the Pueblo district of the Southwest and of Mexico and Central America and most of South America, and most of the Siberian tribes, the European Lapps, and the Alpine race. The "linear" type of man Hooton believes is best exemplified by the Nilotic Negroes, the Turkana, the Suk, the Nandi, the Hamitic Negroids, the Oceanic Negroes, the Australians, the Nordics, some Mongoloids, and American Indians. The type intermediate between these two is not characteristic of any great division of mankind, although it is almost universal among the Polynesians and is predominant in the Mediterranean race.

Hooton does not believe it is possible to relate strongly contrasted types of body build with adaptations for different kinds of diet, for the distribution of human types is not in accord with the dietetic habits to which they are supposed to have been adapted. The tall, slender, long-legged type is called sometimes the "carnivorous" type, yet the Eskimo, who live almost entirely upon animal food, are short, stumpy, and broad; the Pima, Yuma, and many other maize-eating tribes of the Southwest are tall and slender. He believes it is more plausible to relate body build to the endocrine secretions.

Not very much is known about racial physiology. Work with blood groups has yielded tantalizing but somewhat inconclusive information (280). The trouble with most of this work is that it has been done in terms of nationality,

not race. Some of the most widely different peoples are quite alike in percentages of agglutinogens, which leads to the conclusion that in our present state of knowledge blood groupings are to be regarded as being inherited independently of the physical features of race.

Still less is known of racial differences in pulse, temperature, and respiration frequencies. The few studies made in this field give promise of the existence of significant variations.

Klineberg (151) subjects the work done on the racial factor in physiology to a cautious review, and decides that while it is unquestionable that actual group differences in physiological activity do exist, nevertheless it cannot yet be said that these originate in hereditary factors; in fact, the data even hint at the possibility of some other explanation.

More data have been accumulated regarding the racial factor in disease. Aside from high susceptibility to a few of the contagious diseases brought to the New World to which they have not had time to develop a certain degree of immunity, Hrdlička (136) finds that the Southwest Indians are comparatively free from anemia, affections of the breast, of the circulatory system, asthma, liver disorders, cancer, rickets, hernia, idiocy, and insanity. Even where these Indians show a higher incidence than whites in affections of the gastro-intestinal tract, of the respiratory organs, of the eyes, muscular rheumatism and senile arthritis, small-pox, measles, etc., he believes the condition may not be due to constitutional factors but to climatic, hygienic, and dietetic conditions.

The Negroes in the registered areas of the United States, according to Pearl (219), show less disposition to develop carcinoma than do whites, as well as diseases of the nervous system, the endo-

crines, and the skin. But of lower incidence in whites are diseases affecting the respiratory system, the female genitalia, and the skeletal and muscular systems.

The enormous survey conducted by Love and Davenport (180) on 2,500,000 war recruits gives abundant data on racial differences in disease. In general, it appears that Nordics show little tuberculosis and venereal disease, defects and disease of the eye, ear, nose and throat, and developmental defects; they are more susceptible to nervous and psychopathic disorders, functional and organic heart disease, and varicose veins. Alpine groups are even less liable to tuberculosis and venereal disease, and have fewer nervous diseases and less mental deficiency; they are more prone to defects and diseases of eyes, ears, nose and throat, heart disease, and developmental defects. The groups with a good deal of Indian admixture are very superior in their resistance to disease in general, except for being greatly susceptible to tuberculosis and venereal disease.

Tuberculosis is a disease which has been studied extensively with regard to its racial predisposition. Statistics are numerous which seem to indicate that not only is the incidence of the disease higher in Negroes than in whites, but that anatomical and pathological characters of the disease differ racially. Typical of such conclusions are those of Everett (84), who in a study of 75 cases found the "childhood type" of tuberculosis more common in Negroes and the "adult type" more common in whites. Johnson and Myers (143), in a study of tuberculosis in infants and primitive races (Indians of Minnesota, Negroes, and Mexicans), find that these racial groups have approximately the same first-infection kind of reaction to tuberculosis as do whites, but that reinfection tuberculosis is likely

to follow a different course in primitives, —thus doing much to clear up the thinking in this field in recognizing first-infection and reinfection forms of tuberculosis as "almost two distinct diseases." F. J. Halford (120), in a study of school children of Hawaiian blood in the Hawaiian Islands, found among these natives a higher incidence of tuberculous infection, a higher mortality from tuberculosis, and certain other differences in the course of the disease, as compared with other racial groups in the Islands; and found further that racial admixtures exerted a definite influence upon these differences. Bogen (35), in a study of racial and national origins of patients admitted to a sanatorium in California, found that definite differences existed in mortality figures, but felt on examining the figures and circumstances that environmental factors more than accounted for the racial mortality differences.

Stern-Piper (290), Pfuhl (234), Ritterhaus (246) and Henckel (126) believe that Kretschmer's constitutional types are really racial in character and that they are not of chance occurrence within races, as Kretschmer claimed. They assert that the pyknic-cycloid type is actually the Alpine race and that the leptosome-schizothymic type is the Nordic. That a racial factor is involved is denied by von Rohden (316), Wertheimer and Hesketh (327), Weidenreich (323), E. Miller (198) and others. Miller's argument is that there are no indications of a predominance of manic-depressive psychoses in races which are rather pyknic in physique, nor of schizophrenia in races in which the majority of people have athletic-leptosome physique.

In his recently published work on criminal types, Hooton (134, p. 104) very explicitly states that while constitutional

types are associated with the type of criminal offense, he has carefully considered the racial factor and decided that this is only partly responsible for the types.

Not enough work has been done on classification of body build according to race to be certain of facts in this area. But it seems likely from the preliminary observations of a number of individuals that real and statistically significant differences as to body proportions as well as other morphological characteristics do exist between different races.

2. The sex factor in constitution

The sex factor in man's constitution is of clinical importance. Nature produces not only imperfectly sexually differentiated individuals, but also gives to every individual subtle analogies of form and psychic pattern which endow that individual with a certain gynandromorphism.

Draper (71, pp. 135-137) has listed the frequency of disease with relation to sex. In general, it seems that in the case of men it is the mechanism for energy expenditure which is involved; in the case of women, the diseases involve protective and energy accumulating mechanisms.

Inquiring into the cause of differential sex predisposition to certain diseases, Draper ingeniously reasons thus: There is a definite quality of sex to be found in all of the cells of the soma and the expressions of this are the secondary sex characters. The tissue cells of a male react differently from the tissue cells of a female. Therefore these cellular differences are to be regarded as being just as definitely secondary sex characters as are hair distribution, body contour, and psychic pattern. "From the point of view that sex appears as a fundamental quality of somatic tissue protoplasm, it is clear that the susceptibility of certain

diseases must often behave like a secondary sex character." (p. 142.)

Sex thus is an important factor in the study of the morphological and physiological and pathological aspects of constitution. It likewise plays an important rôle in the psychological aspect of constitution, but here the environmental problem has a proportionately greater influence.

Sex, then, is seen to be a constitutional variable in another dimension than those already considered, although undoubtedly it is to some degree correlated with some of them. In all studies of the rôle of sex in constitution it probably is well to study males and females separately, though it is likewise important to keep in mind the rôle of gynandromorphism, as suggested by Draper.

3. Age and growth and the permanence of the constitutional make-up

The factors of age and growth must be considered both as to their influence on constitutional type and their contribution to the understanding of the rôle of constitution in longevity.

Do morphological characters remain unchanged in the face of increasing age and growth? It was the contention of Sigaud (277) and of Viola (308, 309) that the types of habitus which they had delineated were not altered by age, though Sigaud came to give up this belief, which has been contradicted by the work of Zweig (334), J. Bauer (15), and Brugsch (42). According to Brugsch, the narrow-chested type develops to a normal-chested type in one third of all cases between the ages of twenty-five and thirty-five; and the normal-chested type can change with age to a wide-chested type. Mills (199), who lists major morphological types and sub-types, observes that while type may change from one to another, the change is

always from one *sub-type* to another. He studied one thousand persons and found there was no progression from one major class to another.

One major deterrent to the accurate recognition of human morphological types is the undeniable fact that the human body changes size and shape with age, and in addition to doing so under a variety of normal conditions does so under the influence of certain pathological conditions, as the cachexia of advanced cancer or tuberculosis, the adipose changes of pituitary disease, even the skeletal changes of rickets, acromegaly, etc.

To the student of the major changes of the human body for the years of life primarily involved in growth and differentiation, a vast literature is available, among the most reliable studies and summarizations of which seem to have been those of Bardeen, Scammon, and Calkins (10, 256, 257). Several investigators have made serious efforts to classify infants and children according to morphological criteria. Lederer (171) in 1923 found it possible to apply Sigaud's classification quite successfully. Schultz (262) in 1926 was able to distinguish significant individual morphological characteristics even in fetal life. Bakwin and Bakwin (8) made a very thorough study of morphological classification in the early years of life. Ossipowa (214) indicates from her investigations that Kretschmer's morphology and characterology begin early in childhood and that types can be recognized in both dimensions at this stage of development.

Aside from the proportional changes of growth and differentiation, which admittedly make difficult the problem of classifying human morphology in the younger age groups, there are the problems of wide "normal" fluctuations in nutritional status and the less common though

no less real variations in general "condition" or "tonus," especially of the musculature. In other words, it is a matter of every-day observation that individuals may vary considerably with respect to (a) deposits of fat, (b) degree of development of musculature, and even (c) of the more stable skeletal parts of the body, such as degrees of mineralization and osteoporosis of the bones, with age. These fluctuations may well be summed up in the not too specific term "physical status," which may be used primarily to denote degree of fat deposit and muscular development.

The question rightly raised is: Do "normal" changes in physical status, associated with age or other factors, alter the fundamental constitutional picture of an individual? In the sense that there is a marked psychological lability in an individual as the result of many environmental factors, it does unquestionably change. Under certain conditions not only the psychological, but also the physiological and even the morphological pattern of an individual may vary, but such changes may not be said to be "normal." If the question is then rephrased: Do "normal" changes in physical status, associated with age or other factors, alter the fundamental *morphological* constitutional picture of an individual? the problem is more immediately susceptible of accurate evaluation.

Other authors than those mentioned believe that the morphological aspect of constitution does change with age and nutritional status. Wertheimer and Hesketh (327), for example, state that in older individuals there are more pyknics than in younger persons. They quote Möllenhoff (201) as believing the same. Certain it is that if measurements and indices are used as the major determinants of classification of body build, the constitutional picture will change, in that

there will be shifting of indices of body proportions. For example, some investigators say that it is not until the twenty-ninth year that the maximum growth and final proportions of the thorax are fixed. For this reason it would seem proper that different values be given to indices with change from one age group to another. This does not mean that there has been a change from one type of habitus to another but that any habitus undergoes indicial modification with the passage of years. Change in morphological indices with age is especially noticeable if weight is one factor in such an index. Wertheimer and Hesketh (327) point out the important changes in weight in later life, especially associated with certain of the psychoses. Draper states (69, p. 98) "the weight character is obviously not entirely a constitutional factor, but depends upon the momentary state of nutrition," implying that weight is in part a constitutional matter, and is in part affected by the physical status.

Many have been the authors who have examined this matter of nutritional status. Most have sought to evaluate this simply with some "nutritional index," depending largely on some mathematical relationship between weight and some linear measurement, usually stature. Other measurements, as sitting height or chest circumference, have been employed in such indices in an attempt to find a more significant relationship, by Fleischner (91), Guttmann (116), von Pirquet (315), Wagner (320), and many others. Basically, however, a height-weight relationship called a "ponderal index" has been the method of attack on this problem. Among the investigators who have approached this problem of an adequate expression of nutritional status with various nutritional and ponderal indices have been Bardeen (10), Dreyfuss (75),

Emmerson (78), Manny (186), Gerber (100), Livi (175), Matusiewicz (192), Rohrer (247), and Brugsch (42). Among the expressions for the ponderal index that have been used are $\frac{\text{Weight}^{1/3}}{\text{Height}}$; $\frac{\text{Weight}}{\text{Height}^3}$;

$\frac{\text{Weight}}{\text{Height}^{2.5}}$; $\frac{\text{Weight}}{\text{Height}^2}$; $\frac{\text{Weight}}{\text{Height}}$; and their inverses. Kelly (147) in a careful investigation of this problem found the most satisfactory exact index to be $\frac{\text{Weight}}{\text{Height}^{3.042}}$

for males and $\frac{\text{Weight}}{\text{Height}^{2.79}}$ for females, but

that $\frac{\text{Weight}}{\text{Height}^3}$ differed very slightly from these and was adequate for all practical purposes. McCloy and associates (195, p. 105) have adopted $\frac{\text{Weight}^{1/3}}{\text{Height}}$ as the ponderal index of choice, after a very careful consideration of the entire subject. Sheldon (275) has adopted the inverse of this index.

Numerous as have been these efforts to define nutritional status mathematically, they have not succeeded in allowing for the important matter of the relation of the ponderal index to individual variation in body build. One of the best approaches to this vital problem has been that of McCloy and associates (195, 196) at the Iowa Child Welfare Research Station. They take four measurements on the subcutaneous fat (chest front, chest back, supra-iliac, and abdominal) to correct certain transverse trunk measurements; and certain limb (muscular girth and joint diameter) measurements for determining relative musculo-skeletal development; and then by means of suitable formulae and tables are able to give mathematical expression to the individual's relative body build, and so predict the "normal weight" for that particular constitution at that particular age. This

technique is a distinct advance in the somametric analysis of body build, for it enables one to use anthropometric data, including the highly labile one of weight, without indicial distortion.

A particularly able study of the effect of exercise upon the musculature has been made by Arnold (6), in a group of athletes, who, theoretically at least, have the greatest potential lability of this particular part of the soma. Arnold finds that, with exercise, the following changes in body measurements occur: the ponderal index decreases due to loss of fat; shoulder breadth, chest circumference, and the thoracic index increase; other breadth measurements of the trunk, and circumferential measurements of the extremities do not change; in the same age group athletes are generally larger and more robust than a random sample of the population; and leptosomes and pyknics decrease and the athletic type increases in frequency.

It will be clear from this discussion, however, that although bodily indices and proportions may change with exercise, nutrition, etc., it does not necessarily follow that the fundamental kind of morphological make-up (constitution) also changes, for indices are not altogether adequate measurements of the body build. It seems likely that if some such technique as that worked out by McCloy and associates had been applied to Arnold's data, radically different conclusions might have been the result.

As the physiological and psychological make-up are less determined by heredity and more influenced by environment, it is evident that they are less constant and permanent with the passage of time, this being the case more with the psychological aspect than the physiological.

An important contribution to the problem of changes in physical build with

age, as related to the development of disease, has been made by Reed and Love (243a), who followed up the incidence of disease in U. S. Army officers ten to twenty years after their admission to the service, when careful anthropometric measurements had been taken. They found, for example, that individuals who developed tuberculosis had a characteristic body-build, judged chiefly according to a height-weight relationship, as much as twenty years before the appearance of the clinical manifestations of the disease (see section V. C. 4.). The officers aged 21-25 who developed tuberculosis twenty years later had a mean weight of 138.39 lbs., with a stature average of 70 in., as compared with averages of 151.27 lbs. and approximately the same height in the entire group—a difference of 12.88 lbs. And the officers aged 26-35 who developed tuberculosis ten years later weighed 142.95 lbs. on the average, as compared with men of the same height averaging 158.21 lbs. in the general group, a difference of 15.26 lbs. In brief, in every age group those individuals who ultimately were to develop clinical tuberculosis characteristically were of a tall spare build as compared with other officers. This kind of study would seem to go a long way toward meeting the criticisms of many observers of constitutional studies, who suggest that a certain body build found to be associated with a given disease is perhaps the result of that disease rather than a predisposing factor in its development.

Another interesting and fruitful source of inquiry has been suggested by Graves (111) in studying the relation of constitution to longevity. The result of three decades of work with scapular types has convinced him that if certain features of the habitus, not subject to age changes, are found in higher percentages among

older individuals, then it follows that there is some sort of connection between these features and longevity.

Graves' work is worth describing. He noted that the vertebral borders of scapulae were either concave, straight or convex. After long study, he concluded that these variations in contour expressed capacity for adaptation and survival. His studies of individuals, families, and groups led him to state that the concave and straight scapulae are most frequently found in those who are innately remote from the biological ideal in total make-up and adaptation—the weak, the unhealthy, the "plus-potentially unhealthy." Conversely, convex types of scapulae he found occurred most frequently in those who are strong and healthy. Graves claims that the incidence of the convex type increases from 35 per cent to 65 per cent in the successive age periods from birth to old age, and that this must not be construed to mean that scapular type changes, for after the type is once formed there is no change. Graves explains this age incidence as "better adaptability, less morbidity, less mortality and greater longevity among the bearers of the convex than among the bearers of the scaphoid types."

Up until recently, the only investigations of inherited character-types in relation to age and longevity were those on scapulae. Graves (110) has now inspired other workers to make similar studies of other inherited character-types, such as blood groups. Preliminary results, based on too small a sample, indicate that O is most associated with longevity and AB least.

Pearl and Pearl (224) have stated that longevity may be "regarded as a simple numerical expression of the integrated effects of all the forces that operate on the individual, innate and environmental." They believe that though longevity is

undoubtedly affected by all sorts of environmental circumstances, it is nevertheless intimately connected with the biological constitution of the individual. They have shown by a study of nonagenarians and centenarians that "for every year of superior longevity realized by the longevous group, there is a corresponding superiority in the longevity of their immediate ancestors."

Rössle (249) has likewise studied the constitutional factors involved in living to old age, and concludes that longevity is distinctly an inheritable factor, probably associated with definite constitutional patterns. Few if any careful studies, however, have been carried out to determine the morphological classification of the same individual or group of individuals over a period of time.

In order to ascertain the stability of constitutional make-up it would be best to carry on observations on individuals from birth to death. Unfortunately this has never been done, although Graves (109), on the basis of examinations on two hundred individuals for a period of only eighteen years, believes he has established the fact that the shape of the vertebral border of the scapula is determined by the tenth fetal week and does not change with age. Another part of the constitution which is believed not to change throughout life is the individual blood group (see section II. D. 2.).

Treadgold (304) has observed that it is rare for underweight individuals to change to overweight, and vice versa, as determined relative to common weight standards, and it is an every-day observation that while normal weight may change considerably it rarely changes radically from an under- to an over-weight group.

The problem of the possible change of the morphological constitution is an exceedingly complex and difficult one.

Frequently a young man or a young woman in the teens is seen to blossom in later life into the full bloom of a pyknic. This apparent metamorphosis has been sympathetically referred to by Sheldon as a "pyknic practical joke." Any attempt to classify such an individual in early adulthood or earlier solely by strictly anthropometric techniques will not take into account the more elastic structures of the body that are so important in morphological classification. Attempting to measure the soft parts may also lead to error, through faulty techniques or through faulty selection of measurements. It seems likely, at the present stage of constitutional classification, that scopometric classification (see section IV. A. 2. c.) is the most valid, avoiding at once the Scylla of too great subjectivity and the Charybdis of sole reliance on objective measurements; and that, making suitable and adequate allowance for minor changes in physical status, the morphological component-picture, or type, does not change appreciably if at all from birth to death, except under the duress of pathological conditions.

F. Final definition of constitution

Having now considered the nature of constitution from a number of points of view, it will be possible to formulate a meaningful definition of just what constitution is.

Constitution, then, is to be defined as *the sum total of the morphological, physiological, and psychological characters of an individual, with additional variables of race, sex, and age, all in large part determined by heredity but influenced in varying degrees by environmental factors, all of which, when integrated and expressed as a single biological entity, fluctuate in varying degrees over a wide range of "normality" and occasionally cross*

an arbitrary boundary into "abnormality" or pathology.

III. THE UTILITY OF CONSTITUTIONAL KNOWLEDGE

Having examined and defined the nature of constitution, one may well inquire, what is to be gained from a study of constitution?

The main theoretical objectives have been expressed by Pearl and Ciocco (221, p. 30) as follows:

The study of human constitution has for one of its major objectives the discovery of stable organic correlations (integrated biological relations) between the morphological, physiological, psychological, and pathological characteristics of the individual, and eventually the precise numerical measurements of such correlations. In particular, with regard to the relation between somatic constitution and disease, it seeks the degree of consilience between variation in morphology and normal or pathologic physiology; and the part this plays in predisposition and different individual reactions to infectious and other diseases.

Our ultimate interest in these problems is to take advantage of discoveries thus made and the leads which they provide in diagnosis, therapy, prognosis, and prevention. When this branch of science shall have been established on a strong, scientific basis it should be possible, for instance, to study carefully the individual make-up and recognize those variations which may dispose to certain diseases. Draper (71, p. 239) has likened the defenses of the human being to "the famous British square which Fuzzy-Wuzzy broke," whose four sides are seldom equally strong.

Being aware of the assaults of the environment which continually harass the individual constitution, it should be possible to decide where is the Achilles' heel—the *locus minoris resistentiae*—of the individual, and to endeavor to avoid events, objects and personalities which are apt to provoke in him reactions

especially dangerous to the phenotype. Those organic invaders, ways of living, and climatic conditions likely to be most harmful can be avoided, once forewarned.

To aid in understanding those morphological aspects of constitution which are correlated with survival value, Graves (111) has advanced the "age-incidence" principle as a method of qualitative evaluation of the biological significance of the permanent, or relatively permanent, types of inherited characters, whether of structure, function, measurements, or indices. While sound in its logic, Graves' principle has thus far yielded few positive results, primarily because not many research workers have utilized the method.

In addition to contributing possible preventive methods, constitutional knowledge may contribute to actual therapeutic measures. Psychoanalysts have emphasized what good practitioners have known for centuries—that phantasy, imagery and symbolism are important causes of disease. They have been able in many cases to restore disturbed emotional relationships and eliminate disease. Regulation of nutrition, body chemistry, and even internal secretions might be attempted after more is known of their rôle in and influence upon constitution.

In the field of medicine known etiologic agents, even in infectious diseases, probably are only partly the explanation of an individual's susceptibility to a given disease. If it were possible to measure and correlate the amount of an infectious agent (size and virulence of dose) against the degree of clinical pathology associated therewith, the correlation would not be perfect. In different diseases perfect correlation would be approximated to a greater or lesser degree. In childhood, for example, exposure to measles is highly correlated with the development of rubeola; the correlation of the develop-

ment of the paralytic form of poliomyelitis with exposure to the filtrable virus of infantile paralysis is lower. To interpret such a statistical expression would mean, in the first instance, that exposure to measles was nearly all the circumstance required to get the disease in childhood; in the latter, that other factors, not represented in the particular bivariate correlational study, are involved to a greater degree. By suitable statistical devices other possible correlates may be discovered, and their combined correlation, expressed in a suitable statistical manner, may be considerably higher than with the single correlation of the disease occurrence with exposure. It seems likely that in this way constitutional factors can be delineated and measured which will add to the total knowledge and predictability of disease.

The aim in modern medicine is to make a doctor, in the first place, a more accurate diagnostician. With further accurate studies in the field of constitution it should be possible to equip the physician with yet another tool in his armamentarium, this time not another laboratory test, but clinical insight into the restric-

tions of constitutional variation as manifested in disease.

In this connection Coerper (57) summarizes the utility of constitutional knowledge well when he makes a plea for constitutional clinical training as a part of medical training. He points out that to know a disease is one thing, to understand a sick man another; and that methods of constitutional investigation, particularly since the introduction of biometric analysis, are reliable and contribute to the accuracy of diagnosis, prognosis, and therapy, as well as prevention.

Prediction and direction of an individual's biological evolution, however, is a somewhat restricted conception of the possible utility of constitutional investigation. Diagnosis, therapy, and prevention may be considered the chiefly defensive function of man's biological knowledge. Of potentially greater significance is the possibility that, through all scientific knowledge, constitutional and otherwise, man may be so able to control and direct his destinies that true biological evolution will ensue.

(To be concluded)



REGENERATION IN PROTOZOA: A PROBLEM OF MORPHOGENESIS

By WILLIAM BALAMUTH

University of California, Berkeley

I. INTRODUCTION

STUDIES on the problem of regeneration clearly illustrate the dominant trends that have guided the development of protozoölogy. Real contributions to the general subject of regeneration date from Trembley's inaugural work on *Hydra* (1740), following which many other Metazoa were studied. The first intimation of the existence of comparable phenomena in Protozoa was contained in the casual observations of eighteenth century taxonomists and natural historians. In the following century, when the classical studies of Dujardin, Schultze and others had shifted emphasis in protozoölogy to the nature of protoplasm, further incidental records were added. With the discovery of nuclear activity during sexual processes (Balbiani, 1861; Bütschli, 1876; etc.), many came to support the view that the nucleus was the most important constituent of the protozoan cell.

In the late nineteenth century, therefore, the time was ripe to probe the relative rôles of nucleus and cytoplasm in various life processes; regeneration experiments on unicellular organisms afforded a direct method. Unicellular material is desirable in several ways for studies of regeneration. It is possible to separate nuclear and cytoplasmic elements, to remove minute and yet essential constituents, and to correlate nuclear and cytoplasmic activity during the ensuing

regeneration. The course of morphogenesis might be expected to proceed more directly in organisms in which the relation of cause and effect is not masked by multicellularity.

The problem of regeneration has been approached in two general ways. Many investigators have been occupied simply with tracing the regenerative capacity of Protozoa. Often guided by little more than intrinsic curiosity, these descriptive studies have not attacked the basic problem. A more fundamental approach has emphasized the mechanism controlling the regenerative process. The explanation of new-formation of structures has been sought by some investigators in terms of cytoplasmic movements accompanying regeneration; by others, in terms of nuclear activity stimulating the production of formative substances. A few workers have adduced evidence of the activity of physiological gradients during normal and experimental differentiation of Protozoa.

In connection with these studies, it has been found that the regenerative process often simulates the reorganization which accompanies the various phases of a protozoan life history (fission, encystment, and sexual reproduction). In each instance, whether it be a mutilated or otherwise physiologically altered individual, there occurs an initial loss of structural differentiation. Following this process of "simplification" the species-pattern is re-differentiated in all cases by a

fundamentally similar method. This suggests the possibility that one basic mechanism may control both normal and experimental reorganization. If this proves true, then regeneration phenomena too would properly be considered to involve a kind of developmental change.

These various approaches have contributed many data bearing on regeneration. The scope of the present review is to treat the respective groups of Protozoa in the general order of their derivation, and wherever possible to emphasize underlying similarities linking the processes accompanying regeneration and ontogeny. It may be hoped that in this way certain conclusions of general importance will emerge concerning the problems of protozoan organization. Moreover, some of the recent studies on micro-organisms seem to have applicability to more general problems of regeneration. (Discussion of literature bearing on protozoan regeneration may be found also in reports by Bütschli (1887-1889), Przibram (1909, 1929), Sokoloff (1924), and Korschelt (1927).)

II. EARLY ACCOUNTS OF REGENERATION

The older microscopists bore visual witness to the viability of mutilated Protozoa, although in general no effort was made to follow restorative processes. As early as 1769 Ellis had observed the fragmentation of certain ciliates under unfavorable conditions; the surviving pieces continued indefinitely to live and to move. Eichhorn (1783) was stimulated by Trembley's work to test the regenerative response of the large heliozoan, *Actinosphaerium*. In three instances he observed the reconstitution of mutilated individuals. The Italian naturalist, Guanzati (1796), accurately described some interesting form-changes in a hypotrichous ciliate ("*Proteus*"), during which

an extrusion of part of the body was followed by restoration of the normal shape.

In the nineteenth century pertinent data appeared in various sources. Ehrenberg's treatise (1838) contained many references to fragmentation in Protozoa by partial cytolysis. Most of these were misinterpreted as illustrating extrusion of eggs and embryos, which was in conformity with the exaggerated complexity ascribed by Ehrenberg to protozoan structure. In fact, the generic characteristics of *Stentor* included the habit of bearing young by cytolysis (p. 262); similar interpretations were made for *Paramecium*, *Stylonychia*, etc. Accidental fragmentation was also recognized, in *S. mytilus*, for example, "Cytolysis produces remarkably active, viable fragments. . . ." (p. 371). No definite indications of regeneration were given in any part of the work.

At about the same time Dujardin (1838, 1841) incorporated his intensive observations into a series of works. In sharp contrast to Ehrenberg, he denied the existence in Protozoa of definite internal organs; to substantiate his view he pointed out that small pieces of experimentally mutilated *S. pustulata* and *Oxytricha pellionella* continued to live, which would not be expected if the missing parts were highly organized (1838, p. 313; 1841, p. 423). Concerning regeneration Dujardin made the happy surmise for ciliates that, ". . . if, despite their small size, one could cut them into fragments, each part would continue to live and would become a complete infusorian again. . ." (1841, p. 31).

Perty (1852) supported Dujardin's views but did not refer to regeneration. Claparède and Lachmann (1858-1861), on the other hand, opposed these views. They summarized their position by stat-

ing, "... we are not yet convinced that a fragment of any kind from these animals [the ciliates] can reproduce a complete individual." (p. 11).

Stein's monograph (1859) contained scattered references to the survival of fragments of ciliates (*S. mytilus*, p. 151; etc.). He reached the same conclusion as some of the above workers, that many supposed genera of early investigators like O. F. Müller were actually pieces of well-known species. The large hypotrich, *Urostyla*, was observed to recover its normal form and activity following experimental mutilation (pp. 193, 195).

Max Schultze's study of protoplasm (1863) led him to investigate the effect on viability of crushing foraminiferan shells. The miliolid species he used remained active for a short time, but he did not record any regeneration. In Haeckel's collected biological studies (1870) appear references to cutting experiments on *Actinosphaerium*, *Myxastrum* and *Protomyxa* (p. 22, 34). Fragments behaved normally during the brief period of his observations.

Some contributions of little importance include Wreśniowski's observation (1870) that *Stylonychia pustulata* mutilated by predatory *Dileptus* apparently continued to live; Parker's reference (1883) to an alleged "reproduction by partial dissociation" following natural fragmentation of *Amphileptus fasciola*; Worcester's similar account for *Stentor coeruleus* (1884); and Gruber's record for *Oxytricha* sp. (1885a).

III. ORGANIZED STUDIES OF REGENERATION

The previously cited works threw little light on the problem of regeneration beyond indicating a rich, unexplored field. Meanwhile the first organized studies were being made, and since 1880 an ever increasing series of investigations

has probed the extent of protozoan regeneration.

(1). *Mastigophora*

Turning to the groups of Protozoa in the general order of their derivation, we find in the first instance few experiments involving flagellates. Peculiarly enough, the types used have been highly specialized. Kofoid (1908) described regeneration following autotomy in *Ceratium*, an armored dinoflagellate. Depending upon environmental fluctuations, its long horn-like extensions could be lost and replaced by new ones. Huber-Pestalozzi (1922) experimentally induced the breaking of the horns of *Ceratium hirundinella* by centrifugalization. In the subsequently regenerated structures he described a relatively high incidence of malformations ("hyperplastic regeneration").

Noctiluca miliaris is a fragile, luminescent form which is also included within the Dinoflagellida. Webb (1855) definitely noted regeneration in mutilated individuals and thereby satisfactorily disposed of Busch's interpretation (1851), and the later observation by Pouchet (1885), that these represented reproductive stages. Some years later Dönitz (1868) and Cienkowski (1873) described the restorative process in *Noctiluca*. Following injury and the resulting collapse of the turgid cell membrane, the plasma network retracted to the central mass around the nucleus. New-formation depended on the extent of injury; it could consist in the differentiation of a new cell wall from the vesicular periphery of the central mass, the discarding of the old cell wall, and the subsequent development of staborgan, flagellum, and remaining structures. In its most complete expression, experimental reorganization seems to simulate the changes occurring in the

division process. Cienkowski went further in making experimental tests of the regenerative potencies of various fragments, concluding, "Even in very minute bits of protoplasm the essential organelles of *Noctiluca* can be formed *de novo*." (p. 52). The most extensive cytological study of *Noctiluca* was made by Pratje (1921). His observations on regeneration were limited to an account of the replacement of an injured cell membrane and its derivative, the staborgan. He recorded the migration of central plasma and nucleus to an injured site, where cytoplasmic threads were sent out, and the subsequent return of these wandering elements to a sub-cytostomal position.

A novel approach was employed by Hübner (1902) on a complex colonial phytomonad, *Volvox globator*. He tested the ability of somatic cells to restore experimentally removed sectors of the spherical colonies, which are composed of somatic and germinal cells. In more than 200 operations of various kinds, isolated groups of somatic cells failed uniformly to regenerate mutilated colonies. Individual cells were too small to test intracellular potencies. Without reference to the preceding, Bock (1926) worked on a series of colonial phytomonads: *Gonium pectorale*, *Pandorina morum*, *Eudorina elegans*, and *Volvox aureus*; only the last possesses germinal and somatic differentiation. By testing the reactions of isolated cells, he sought to determine whether the Volvocidae represented colonial or multicellular individuals. He found that with advancing complexity in the series, the effects of mutilating colonies became increasingly severe. Thus while cells of *Gonium* and *Pandorina* regularly restored entire colonies, *Eudorina* cells produced only incompletely formed dwarf colonies, and *Volvox* cells

died with no evidence of multiplication. These experiments indicate that mature somatic cells of the Volvocidae cannot regenerate a colony. It should prove interesting to trace this reaction back through the earlier stages of differentiation in a *Volvox* colony. Pietschmann (reported in Przibram, 1909, p. 8) found that operations on young daughter-colonies of *Volvox* produced the same negative effect as in Hübner's experiments, but apparently no attempt was made to test cleavage stages.

(2). *Sarcodina*

Of the Sarcodina the relatively simple Amoebida were among the first used for regeneration studies. Greeff (1867) effected fragmentation in a large unnamed form (probably *Pelomyxa*), with the result that most of the fragments developed into completely normal individuals. Unaware of the multinucleate condition of *Pelomyxa*, Greeff concluded simply that experimental divisibility was probably widespread among Rhizopoda. A. Gruber (1886) amplified this finding in his study of *Amoeba proteus*. He showed that while nucleate pieces regenerated normally, enucleate individuals became spherical and died within a few days.

Subsequent workers have used amebae for various experimental purposes; some of the results seem pertinent to the problem of the rôle of the nucleus and cytoplasm in regenerative processes. Through his extensive experiments on *A. proteus*, Hofer (1890) undertook to reinvestigate the problem of nuclear versus cytoplasmic control of various cellular functions. His protocols of regeneration added a more detailed analysis of Gruber's results. LeDantec's study of digestion (1894) revealed only the fact that enucleate *A. proteus* and *Gromia*

fluvialis could not assimilate and consequently degenerated. Penard's treatise on rhizopods (1902) recorded fragmentation of *Pelomyxa* spp. and *A. fluida* under unfavorable conditions, and the regeneration of nucleate pieces (p. 142). His observations of pellicular amebae (1905) disclosed that enucleate *A. terricola* could heal a mutilated pellicle, but it survived only five days. Grosse-Allermann (1909) was able to keep enucleate fragments of this species alive for 25 days without observing regeneration. Stolc (1910) recorded the culture of enucleate *A. proteus* for 30 days. He claimed that digestion occurred in these fragments without the subsequent assimilation necessary for regeneration.

K. Gruber (1912) noted that removing a portion of the cytoplasm of *A. proteus* resulted in a corresponding decrease in nuclear volume. This supplied evidence of a physical interaction between cytoplasm and nucleus, quite apart from any chemical interchange which may occur during periods of morphogenesis. Willis' observations on the behavior of *A. proteus* (1916) included the interesting fact that only nucleate pieces could attach to the substratum (which Dellinger, 1906, had shown to occur in normal locomotion). This is probably a factor in explaining the normal behavior and survival only of nucleate fragments.

The regeneration process was used by Hartmann (1924; 1928) to act as a substitute for normal binary fission in *A. proteus* and *A. polypodia*. By regularly removing a small amount of cytoplasm before the time of normal division, he was able to inhibit reproduction during the four months' duration of his experiments. This was for Hartmann an experimental demonstration of the potential immortality of protozoan individuals, amplifying Weismann's well-known theoretical con-

siderations of the potential immortality of a clone of Protozoa. Work on ciliates has extended this approach (see Bauer and Granowskaja, 1934). The less complete results of Phelps (1926) for *A. proteus*, during an experimental period of 32 days, corroborated the above findings.

In amebae regeneration obviously can apply only to restoration of cytoplasm, and possibly of a new cell membrane at a site of injury. The shell-formations of the Testacea and Foraminifera introduce additional derived structures for experimentation. The shells of Testacea are composed either of chitinoid membranes (*Arcella*, etc.), secreted platelets (*Euglypha*, etc.), or foreign accretions (*Diffugia*, etc.). Verworn (1888) could observe no shell regeneration in experimentally mutilated *D. urceolata*. Penard (1900) reported similarly for four other species of *Diffugia*, and Okada (1930) for a fifth; while Martini (1905) and Hegner (1920) added similar observations for five species of *Arcella*. In all instances the mutilations were preserved and adjustments in behavior resulted.

The more complex Foraminifera have yielded some important data bearing on regeneration. Dujardin (1835) was probably the first to observe the continued activity of crushed fragments of a species of the Miliolidae, without pursuing the implications of this fact (p. 351). There followed a series of reports treating of regenerative growth in Foraminifera. From a study of preserved shells, Carpenter, Parker and Jones (1862) gave a description of the regeneration of mutilated chambers in *Orbitolites* sp. They likened the process to the healing of an ulcerated surface. The Challenger expedition material studied by Carpenter (1883) and Brady (1884) furnished additional evidence that *Orbitolites* possesses great regenerative ability. In *O. tenuissima*,

for example, Carpenter reported that "... even a mere fragment broken away from the margin of a disk may suffice to originate a new one" (p. 19).

Bütschli (1886) made the important observation on normal young specimens of *O. complanatus* that its nuclei tended to accumulate peripherally at the site of shell secretion. This fact was corroborated by Verworn (1888) and by Rhumbler (1902) for several Foraminifera. Verworn's analysis of shell regeneration in *Polystomella crispa* showed further that

regeneration in the former case alone probably rests, therefore, on the different developmental potentialities of the two groups of organisms.

Rhumbler's exhaustive study of shell formation in Foraminifera (1902) led him to support Verworn's view that the foraminiferan nucleus plays a direct secretory rôle in the regenerative process. The only negative record seems to be Schultz's experimental study (1915) on *Astrorhiza limicola*. Excision of radial projections from the shell (through which

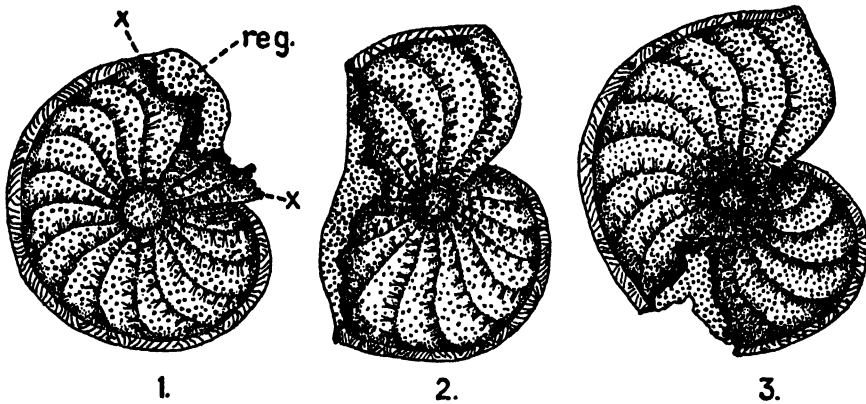


FIG. 1. THREE CASES OF REGENERATION FOLLOWING EXCISIONS IN A FORAMINIFERAN, *POLYSTOMELLA* (= *ELPHIDIUM*) *CRISPA*

Note that in each case the newly forming shell is secreted as a calcareous mass which is held in common by all of the cut chamberlets. x x = line of excision; reg. = regenerating shell. (After Verworn, 1888, redrawn and slightly modified.)

nucleate fragments uniformly repaired shell injuries, while enucleate individuals survived almost three weeks without any evidence of regeneration (Fig. 1). This was apparently clear-cut evidence of secretory activity of the nucleus in shell formation. Comparing this case with the wholly negative results he obtained in Testacea, Verworn pointed out that whereas the foraminiferan shell continues to grow during most of its lifetime, the testacean shell is completely formed in one step at periods of cell division (Fig. 2). The existence of the capacity for

rhizopodia are normally extruded) evoked local healing but no regeneration. Since *Astrorhiza* is known to have a highly variable shell contour, no integral loss to the organism was involved in these experiments. It is surprising that further investigations have not been undertaken on such excellent research material, especially in view of the current emphasis on morphogenetic studies.

The axopodia-bearing Heliozoa were experimented upon as early as 1867, when Greeff effected fragmentation in *Actinosphaerium eichbornii*. As in the previously

cited case of *Pelomyxa*, he noted no connection between survival and the composition of the viable fragments. Brandt (1877) repeated these experiments. He became the first protozoölogist to state that only nucleate fragments survive and regenerate: "This series of changes [i.e., regeneration] occurs only in fragments containing at least one nucleus; enucleate fragments and isolated nuclei themselves degenerate" (p. 30-1).

nucleate base, erect stalk and a capitate upper end bearing skeletal plates and axopodia. Zülzer's lengthy study of this form (1909) included a few regeneration experiments. Of 18 decapitated individuals, 3 survived; each regenerated a complete "head," with new central kinetic granule, axopodia and peripheral platelets. The removed enucleate "heads" did not regenerate, but died after a brief time. More experimental work is needed

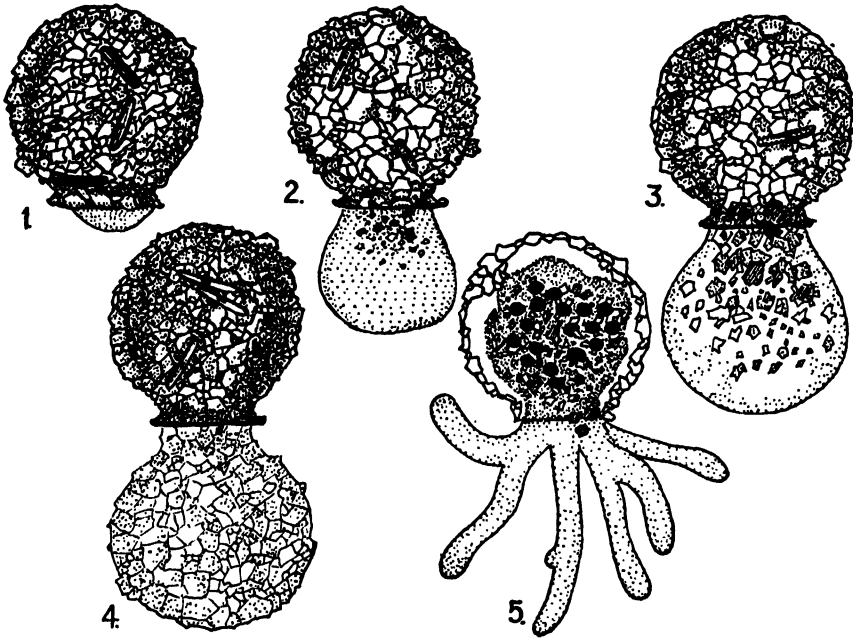


FIG. 2. ASEQUAL REPRODUCTION IN A TESTACEAN, *DIFFUGIA URCEOLATA*

1-4. The newly forming shell is constructed from foreign particles held in reserve by the parent. 5. A dissected individual showing normal extrusion of pseudopodia. (After Verworn, 1888, redrawn.)

Gruber's work on *Actinophrys sol* (1883 a and b) stands in direct contradiction to this view, but Gruber himself soon afterward modified his opinion that the nucleus participated only in the reproductive function. His data were not convincing, being limited to a brief observation of supposedly "normal" enucleate fragments.

Wagnerella borealis is a remarkably differentiated, sessile heliozoan; it has a

on this genus to establish its complete regenerative potencies, and to investigate the cytological aspects of reconstitution.

The highly evolved Radiolaria have yielded very few studies of regeneration, but these indicate the favorable nature of such material. Schneider (1867) removed the central capsule from *Thalassicola nucleata*, a peripylean type. This nucleate mass was viable, restoring the missing layer of extra-capsular cytoplasm and

axopodia, and assuming a normal vegetative existence (Fig. 3). This provided a view that extra- and intra-capsular regions

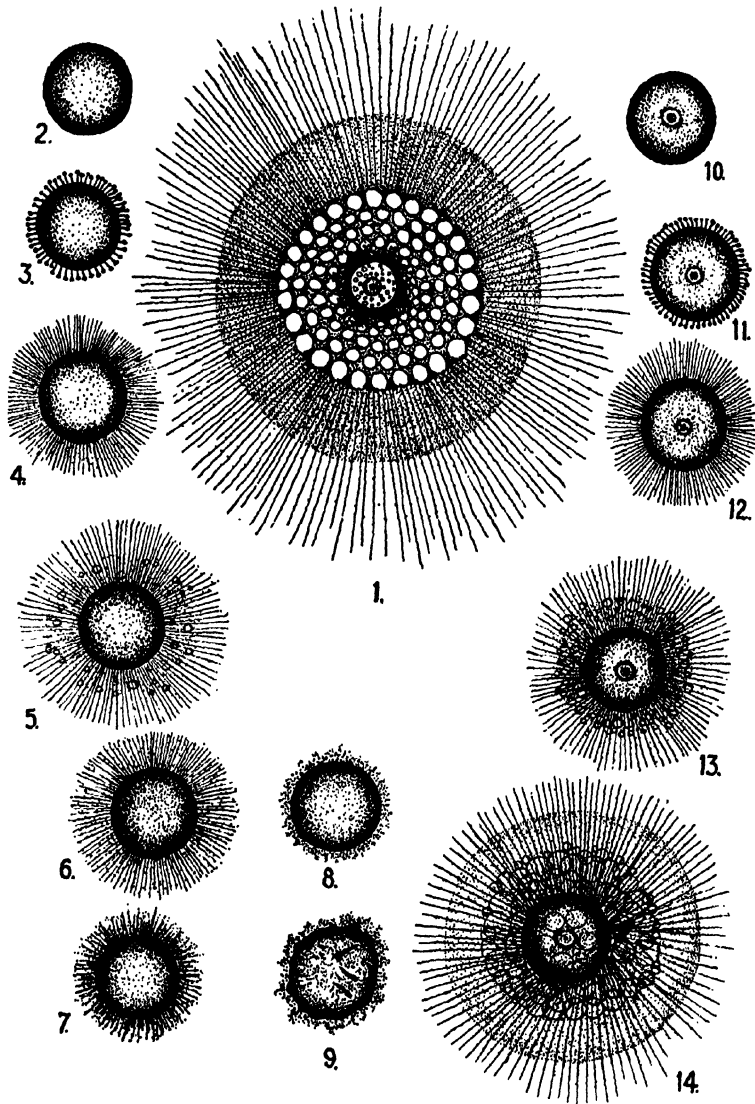


FIG. 3. THE REGENERATIVE RESPONSE IN A RADIOLARIAN, *THALASSIOSIRA NUCLEATA*

1. A normal individual in cross-section, showing the nucleus within the central capsule. 2-9. Granular degeneration of an isolated central capsule following extirpation of the nucleus. 10-14. Normal regeneration in an intact central capsule. (Based on Verworn, 1892, redrawn and modified.)

the first proof of the dominant rôle of the central capsule in the radiolarian organ- represented two independent unities. The less complete observations of Cienkowski

(1871) and Hertwig (1876) corroborated Schneider's results.

Using the same species, Verworn (1892) made some complementary discoveries attesting the important rôle of nuclear material. After showing that isolated extra- and intra-capsular cytoplasm invariably degenerated following a brief period of normal activity, he implanted a foreign central capsule into an isolated mass of extra-capsular cytoplasm. The resulting complex was perfectly normal. An important experiment still to be undertaken for the regeneration problem is the heteroplasmic implantation of a central capsule. Since pronounced species-differences occur in pigment distribution, external form, behavior, etc., the rôle of the nucleus in forming their specific pattern could be tested.

(3). *Sporozoa*

The parasitic Sporozoa stand in sharp contrast to the previous free-living groups. The few regeneration experiments performed on these forms have involved cephaline gregarines and have proved negative. Dembowski (1913) made a few cutting experiments on *Stenophora juli* and *Nina gracilis*. He noted a better locomotor ability in anterior fragments, but he made no comments on their regenerative capacities. Sokoloff's paper (1924) included experiments on *S. juli* and *Gregarina salpae* which were designed to test regeneration. The only positive result was the healing of mutilated cuticle at a site of injury, particularly in the posterior region. Sokoloff's conclusion was that the power of regeneration is poor in these parasitic forms. Although his conclusion may prove correct, yet his inability to culture even normal individuals and his failure to supply a nutrient medium make desirable a more carefully

controlled series of experiments on Sporozoa.

(4). *Ciliata*

(a). Restorative regeneration

The highly organized ciliate Protozoa have proved particularly well adapted for studies on regeneration. On the one hand, complex locomotor and trophic organelles permit a ready study of cytoplasmic restitution; on the other, striking nuclear changes occur during regenerative processes. Yet few investigators have attempted experimentally to correlate nuclear and cytoplasmic reorganization by some causal mechanism. From another approach, systematic experiments on the diverse types of ciliates should give some insight into the degree of relationship among various groups. Since no organized studies have been attempted in this direction, the present review will attempt to compensate for this omission by grouping the results on a comparative basis.

As a result of injury, factors determining recovery and regulation are set into motion which are prerequisites to regeneration. The factors determining recovery are the first to operate following *merotomy* (a term introduced by Balbiani (1888) to designate the process of cutting a protozoan into fragments). It has been found that a fluid cytoplasm, or a pellicle rendered less elastic by peripheral trichocysts, may hinder closure of wounds in *merozoa* (a term introduced by Johnson (1893) to refer to fragments produced by merotomy) and the subsequent onset of restorative processes. Furthermore, important regulatory processes are involved in cytoplasmic movements repairing body shape, and in readjustments of osmotic relations, of locomotor coördination and of the size of organelles. A combination of these

factors probably explains why some closely related types have reacted so differently to experimentation (cf. Table I).

Two types of regenerative response will be considered in order, a reaction to physical injury ("restorative regeneration," Morgan, 1901a), and a response to some less definite, internal cause ("physiological regeneration"). Whenever the data permit, regenerative responses of a given genus will be treated under the following headings: general regenerative capacity; the mechanics of the regenerative process; and the rôle of the nuclear apparatus.

(1). *Regeneration in vegetative individuals*

Paramecium was one of the first holotrichous ciliates to be used for regeneration experiments. Gruber (1886) performed a single experiment, and found that the anterior region of the body regenerated in one day. Balbiani's comprehensive study (1893) included mass cutting experiments on *P. "aurelia"* (= *caudatum*). Its extremely slight regenerative capacity was traced in part to a thick outer layer of trichocysts hindering wound closure. Restoration of normal form often required several generations, and depended on the presence of abundant food. A few comparative experiments on *P. bursaria* indicated a similar response. Jennings' experiments (1908) on vegetative *Paramecium* (*caudatum*?) were uniformly unsuccessful. He concluded that "Whenever the ectosarc is punctured, the internal contents flow out and the animal dies" (p. 615).

Calkins' detailed study of *P. caudatum* (1911b) involved hundreds of individuals cut in various ways. About 30 per cent remained active after 4 hours, but of 149 selected experimentals only 4.7 per cent regenerated. In the giant races which

he used, however, regeneration varied from 1 per cent in one race to 100 per cent in a fourth. To explain the characteristic unequal fission of merozoa, Calkins postulated an irreversible division zone in the center of the cell which was not regulated to suit a given exigency. Peebles (1912) independently confirmed Calkins regarding racial variation, but emphasized that in all cases the outcome of merotomy depended on the physiological condition of the individuals used. Thus a viscid cytoplasm and abundant food ensure regeneration in 90 per cent of the cases, while young, less viscid cells perish in the same proportion because of diffidence. The general regenerative capacity was fair, even discounting her elimination of all individuals not surviving at least 24 hours. Of 83 individuals cut anteriorly, for example, 34 per cent regenerated their missing parts at the cut surface before dividing, while an additional 51 per cent divided in the original plane before any regeneration occurred. Two later workers reporting poor regenerative ability in this species were Chejfec (1932), who found that typical regeneration seemed to occur only posteriorly, and Hosoi (1937), who noted no regeneration during his study of behavior.

The most comprehensive work on *Paramecium* is the recent analysis by Tartar (1939). Using 7 species (Table I), he reinvestigated the alleged racial variation in regenerative capacity. By differentiating sharply between failure to recover from merotomy and inability to restore lost organelles, Tartar could find "... no racial or even species variation of a general ability to regenerate in the genus *Paramecium* as has been previously held." Of 865 anterior cuts, for example, he eliminated 356 as failing to survive; 98 per cent of the remaining merozoa

PROTOZOAN	AUTHOR AND DATE	SCOPE OF WORK
<i>Prorodon</i> sp. <i>terre</i>	Blochmann (1887-89) MacDougall (1925)	Effect of pressure on body Extent of regen.
<i>Pseudoprorodon</i> (= <i>P.</i>) <i>niveus</i>	Balbani (1888)	Rôle of nuclear apparatus
<i>Lacrymaria oliv</i>	Verworn (1888)	Rôle of nuclear apparatus
<i>Spathidium</i> "spatula" <i>spatula</i>	Moody (1912) Moore (1924)	Interdiv. age and regen. capacity Regen. during life history
" <i>Amphileptus incurvatus</i> " (?)	Lepsi (1926)	Occurrence of regen.
<i>Loxophyllum mulsagris</i>	Holmes (1907)	Rôle of body movements in regen.
<i>Dileptus anser</i> <i>anser</i> <i>anser</i>	Balbani (1893) Sokoloff (1924) Vápeník (1927)	Extent of regen. Extent of regen. Effect of repeated merotomy
<i>Trachelius ovum</i> <i>ovum</i>	Balbani (1888) Hamburger (1903)	Rôle of nuclear apparatus Check of Balbani
<i>Loxodes rostrum</i> <i>rostrum</i>	Gruber (1886) Balbani (1893)	Extent of regen. Extent of regen.
<i>Tillina magna</i>	Gregory (1909)	Extent of regen.
<i>Paramecium</i> sp. <i>caudatum</i> <i>caudatum</i> <i>caudatum</i> <i>caudatum</i> <i>caudatum</i> <i>caudatum</i> <i>caudatum</i> <i>caudatum</i> <i>caudatum</i> <i>caudatum</i> <i>bursaria</i> <i>bursaria</i> <i>aurelia</i> <i>trichium</i> <i>polycaryum</i> <i>woodruffi</i> <i>P. multimicronucleatum</i>	Gruber (1886) Balbani (1893) Wallengren (1902) Jennings (1908) Lewin (1910) Calkins (1911b) Peebles (1912) Chejfec (1932) Schwartz (1934) Hosoi (1937) Tartar (1939) Balbani (1893) Tartar (1939) Tartar (1939) Tartar (1939) Tartar (1939) Tartar (1939) Tartar (1939)	Occurrence of regen. Extent of regen. Inanition phenomena Inheritance of mutilations Rôle of nuclear apparatus Extent of regen. Extent of regen. Influence of envtl. factors Rôle of Mi Cyclosis in merozoa Reinvestigation of "regen. power" Extent of regen. See <i>P. caudatum</i> <i>caudatum</i> <i>caudatum</i> <i>caudatum</i> <i>caudatum</i> <i>caudatum</i>
<i>Frontonia leucas</i> <i>leucas</i> <i>leucas</i> <i>leucas</i> sp.	Gruber (1886) Balbani (1888) Popoff (1908) Sokoloff (1924) Hartmann (1922)	Extent of regen. Rôle of nuclear apparatus Nucleo-plasmic ratio and fission Extent of regen. Occurrence of regen.
<i>Glaucoma scintillans</i>	Prowazek (1901)	Rôle of nuclear apparatus

zoa, arranged according to taxonomic relationships

EN. REGEN. CAPACITY	ROLE OF NUCLEAR COMPLEX	REMARKS
		Regen. of new pellicle and cilia Few, unsystematic experiments
Good	Regen. only in nucleate merozoa	
	Regen. only in nucleate merozoa	Incidental experiments
Good		Few experiments; supports Calkins ('11a) Poor regen. capacity during conj.
	Regen. only in nucleate merozoa	Few (one?) experiments
Good		Movements comprise secondary factor
Good Good Good	Partial regen. in enucl. merozoa	Very rapid regen. Evidence not convincing More rapid regen. Few experiments
Fair Good	Regen. only in nucleate merozoa Presence of Ma necessary	Few experiments More extensive than above
Negative Good		Few experiments Slow regen. (4-5 days)
Fair		Few experiments
Poor Negative Poor Fair Poor Negative Good Poor Good Good Good Good Good	Regen. only in nucleate merozoa Ma degenerates; Mi unaffected Regen. of a-Mi merozoa with Ma Mi is important for viability Regen. only in nucleate merozoa	1 experiment; ant. end regenerated Nuclear control of regen. believed lost Hunger-changes are reversible Death invariably follows merotomy Limited viability of a-Mi clone Racial variation in regen. capacity Indiv. variation in regen. capacity Hunger and lower pH favor regen. Brief report; supports Lewin ('10) No regen.; cyclosis normal in merozoa Importance of survival factor noted Few experiments Zoöchlorellae do not aid viability See <i>P. caudatum</i> See <i>P. caudatum</i> See <i>P. caudatum</i> See <i>P. caudatum</i> See <i>P. caudatum</i>
Poor Poor Fair Negative	Regen. only in nucleate merozoa N.-p. ratio controls fission	Few experiments Regen. only after transverse cuts Incidental reference to regen. Failed to survive merotomy
	Regen. only in nucleate merozoa	Few, unsystematic experiments

TABLE I—

PROTOZOAN	AUTHOR AND DATE	SCOPE OF WORK
<i>Colpidium colpoda</i>	Balbani (1893)	Extent of regen.
<i>Spirostomum ambiguum</i> <i>ambiguum</i> <i>ambiguum</i> <i>ambiguum</i>	Gruber (1886) Balbiani (1888) Sokoloff (1924) Seyd (1936)	Extent of regen. Rôle of nuclear apparatus Extent of regen. Regulation of injuries
<i>Blepharisma undulans</i> <i>undulans</i>	Moore (1924) Nadler (1929)	See <i>Sparbidium</i> Induction of regen. of pellicle
<i>Candyllostoma sp.</i>	Tartar (1938b)	Quantity of Ma and regen.
<i>Climacostomum virens</i>	Gruber (1886)	Extent of regen.
<i>Fabrea salina</i>	Balbani (1893)	Rôle of nuclear apparatus
<i>Stentor coerules</i> <i>coerules</i> <i>coerules</i> <i>coerules</i> <i>coerules</i> <i>coerules</i> <i>coerules</i> <i>coerules</i> <i>coerules</i> <i>coerules</i> <i>coerules</i> <i>coerules</i> <i>coerules</i> <i>coerules</i> <i>coerules</i> <i>coerules</i> <i>coerules</i> <i>coerules</i> <i>polymorphus</i> <i>polymorphus</i> <i>polymorphus</i> <i>ignis</i>	Gruber (1885a) Gruber (1885b) Gruber (1886) Verworn (1888) Schuberg (1890) Balbiani (1891b) Balbiani (1892) Johnson (1893) Lillie (1896) Morgan (1901b) Stevens (1903a) Prowazek (1903a) Popoff (1909) Ishikawa (1912) Prowazek (1913) Hartmann (1922) Burnside (1929) Causin (1931) Hetherington (1932) Schwartz (1934; 1935) Gruber (1886) Balbiani (1893) Lillie (1896) Balbiani (1893)	Extent of regen. Rôle of nuclear apparatus Extent of regen. Rôle of nuclear apparatus Site of anlage in div. and regen. Analysis of "double monster" Rôle of nuclear apparatus Extent of regen. Minimal reorganization mass Proportionate regen. of structures Mechanism of peristome regen. Rôle of nuclear apparatus Relation of nuclear to body size Healing and regen. processes Form-determination ("Morphe") Repeated regen. versus fission Relation of nuclear to body size Similarities between div. and regen. Relation of envt. to physiol. regen. Rôle of Ma and of Mi in regen. Extent of regen. Rôle of nuclear apparatus Minimal reorganization mass Rôle of nuclear apparatus
<i>Bursaria truncatella</i> <i>truncatella</i> <i>truncatella</i> <i>truncatella</i> <i>truncatella</i>	Lund (1917) Joff (1923) Sokoloff (1924) Schmährl (1926) Hartmann (1922)	Normal versus experimental reorgn. Rôle of mitochondria in regen. Extent of regen. Mechanism of peristome formation Occurrence of regen.
<i>Licnophora aurbachii</i> <i>majalandi</i>	Stevens (1903b) Balamuth (1939)	Extent of regen. Extent of regen.
<i>Uroleptus mobilis</i> <i>mobilis</i>	Calkins (1921) Tittler (1938)	Effect of merotomy during conj. Regen. after injury by electricity
<i>Uromyla yendis</i>	Fauré-Fremiet (1910)	Regen. response and stage of div.

Continued

GEN. REGEN. CAPACITY	ROLE OF NUCLEAR COMPLEX	REMARKS
Negative		Few, unsystematic experiments
Negative Good Good Fair	Regen. only in nucleate merozoa	Rapid disintegration of merozoa 1 case of incomplete, enucleate regen. Middle-third region regenerates best Regulative regen. of peristome noted
Good	Presence of Ma necessary	Regen. of a-Mi dividing forms Pellicle can be shed and regenerated
	Regen.-time is function of Ma vol.	Various types of abnormal regen. noted
Good		Regen. in 24 hours; few experiments
Good	Regen. only in nucleate merozoa	Few experiments
Good Good	"Nucleus not necessary for regen." "Nucleus is necessary for regen." Regen. only in nucleate merozoa Regen. only in nucleate merozoa	Brief report; few data Reversal of opinion in '85a Only few new experiments Incidental experiments Few experiments; confirms Gruber ('86) Monster formed by incomplete merotomy Exhaustive study at various stages Confirms Balbiani independently Min. regen. mass is $\frac{1}{3}$ original mass Proportionate regulation noted Some regen. in enucleate merozoa Poor factual evidence Heritable size-differences produced (?) Regen. of lost membranelles in situ Ectoplasm controls "Morphe"
Good Good Good	Dual nuclear apparatus causal Ma believed to control regen. Regen. only in nucleate merozoa Regen. only in nucleate merozoa Regen. under nuclear influence Partial regen. in enucl. merozoa "N.-p. ratio controls regen."	Repeated regen. substituted for div. No heritable size-differences produced Regen. regarded as "abortive fission" No physiol. regen. in controlled media 2 viable a-Mi clones produced Regen. within 24 hours Results as for <i>S. coerules</i> Results as for <i>S. coerules</i> Results as for <i>S. coerules</i>
Good Good Good	Regen. only in nucleate merozoa Regen. only in nucleate merozoa Ma alone is proved necessary Regen. only in nucleate merozoa Regen. only in nucleate merozoa Regen. only in nucleate merozoa	Dedifferentiation likened to autolysis Mitochondria accumulate at wound Evidence is questionable Disagrees with Sokoloff's results Encysted following merotomy
Good Fair Good	Partial regen. in enucl. merozoa Presence of Ma held necessary	Observations incomplete Basal disc is never regenerated
Limited Good	Ma and Mi held necessary Ma alone is proved necessary	Reorgn. without cross-fertilization Favors necessity of Ma and Mi in regen.
Good		Notes stage of irrevers. determination

TABLE I—

PROTOZOAN	AUTHOR AND DATE	SCOPE OF WORK
<i>Amphisia</i> (?) sp.	Dembowska (1926)	Comparison with <i>Stylonychia</i>
<i>Stylonychia sterkii</i>	Garnjobst (1937)	Regen. after accidental injury
<i>Plumotricha</i> sp.	Hewitt (1914)	Behavior of Mi in regen.
<i>Gastrostyla</i> (?) vorax sp.	Nussbaum (1884; 1886) Bauer & Granowskaja (1934a)	Limitations of regen. capacity Nuclear and respiratory changes following merotomy
sp.	Bauer & Granowskaja (1934b)	Dependence of "indiv. immortality" on interdiv. age in regen.
<i>Oxytricha fallax</i> <i>fallax</i> sp.	Ishikawa (1912) Reynolds (1932) B. & Gr. (1934a & b)	Healing and regen. processes Rôle of Mi See <i>Gastrostyla</i>
<i>Actinotricha</i> sp.	Dembowska (1926)	Comparison with <i>Stylonychia</i>
<i>Stylonychia pustulata</i> <i>pustulata</i> <i>mytilus</i> <i>mytilus</i> <i>mytilus</i> <i>mytilus</i> <i>mytilus</i> <i>mytilus</i> <i>mytilus</i>	Dujardin (1841) Prowazek (1898) Balbiani (1899) Prowazek (1903b) Lewin (1911) Ishikawa (1912) Dembowska (1925) Young (1926) Dembowska (1938)	Effect of mutilation Occurrence of regen. Action of salt solutions Regen. during "depression" Behavior of Mi in regen. Healing and regen. processes Comparison of fission with regen. Behavior of nuclei in regen. Effect of hunger on reorgn.
<i>Diophrys</i> sp.	Dembowska (1926)	Comparison with <i>Stylonychia</i>
<i>Uronychia transfuga</i> <i>transfuga</i> <i>setigera</i> <i>setigera</i> <i>binucleata</i> <i>uncinata</i>	Calkins (1911a) Dembowska (1926) Young (1922) Dembowska (1926) Young (1922) Taylor (1928)	Interdiv. age and regen. capacity Comparison with <i>Stylonychia</i> Reinvestigation of Calkins Comparison with <i>Stylonychia</i> Rôle of Mi Comparison of fission with regen.
<i>Euplotis patella</i> <i>patella</i> <i>patella</i> <i>charon</i> <i>vannus</i>	Taylor (1920) Taylor (1923), and Taylor & Farber (1924) Reynolds (1932) Dembowska (1926) Dembowska (1926)	Function of neuromotor system Rôle of Mi Rôle of Mi Comparison with <i>Stylonychia</i> Comparison with <i>Stylonychia</i>
<i>Zoothamnium alternans</i>	Summers (1938a & b)	Normal and regulative growth
<i>Vorticella</i> sp.	Runyan & Torrey (1914)	Regulatory development of cilia
Unidentified ciliates	LeDantec (1897)	Behavior of nuclear apparatus
<i>Anoplophrya filum</i>	Sokoloff (1924)	Extent of regen.
<i>Opalina ranarum</i> <i>ranarum</i> <i>ranarum</i>	Nussbaum (1884; 1886) Joff (1923) Sokoloff (1924)	Extent of regen. Rôle of mitochondria in regen. Extent of regen.

Concluded

GEN REGEN. CAPACITY	ROLE OF NUCLEAR COMPLEX	REMARKS
		Few, unsystematic experiments
		Regen. occurs normally within cyst
		No. of Mi remains constant (Lewin, '11)
	Regen. only in nucleate merozoa Nuclear changes only in "adult" merozoa	First such proof for ciliates Marked increase in respiration in "adult" merozoa Only "adult" individuals survive repeated merotomy
Good	Ma and Mi held necessary	Describes healing process Supports Dembowska ('25) See <i>Gastrostyla</i>
		Few, unsystematic experiments
Good	Regen. only in nucleate merozoa	Hypothecates regen. of merozoa Few, unsystematic experiments
Good	Regen. only in nucleate merozoa	Slow dissolution of body in salt soln. Incomplete set of observations
Good		Mi divide in $\pm 50\%$ cases of merotomy
Good	Regen. only in nucleate merozoa	Reports regen. of 2 enucl. merozoa
Good		Div. and regen. follow similar course
		Simult. nuclear and cytoplasmic reorgn.
		"Physiol. regen." is due to hunger
Good		Supports work on <i>Strylonychia</i>
Good	Ma alone is nec. at maturity	Regen. capacity is best at time of div.
Good	Ma and Mi must be present	Supports Calkins on vegetative forms
Good	Ma and Mi necessary in division	Supports Calkins fully
Good	Ma and Mi seem to be necessary	Additional corroboration of Calkins
Good		Condens.-dispers. theory of reorgn.
	Mi is essential for viability	Incidental references to regen. A-Mi merozoa die after max. of 2 divs.
	Ma and Mi must be present	Evidence of racial variation
	Ma and Mi must be present	Few experiments. Regen. is slow
	Ma and Mi must be present	Few experiments. Regen. is slow
Good		Term. macrozooid exerts physiol. dom.
		Stalk exerts dom. effect
	Holds that Ma regenerates new Mi	Data are unreliable
Poor		Posterior region regenerates best
Negative		Disintegration without healing
Very poor		Mitochondria accumulate at wound
		Few cilia appear at cut surface

regenerated and divided. These data seem to indicate that the condition of given individuals may be a decisive factor in determining the outcome of merotomy. Tartar dissociated the rapid regeneration of mouth and gullet as a primary response from the secondary regulation of cell shape, the latter occurring only after feeding had begun. In all instances the missing parts were formed directly at the cut surface (Fig. 4). As Tartar's work

is not favorable for experimentation. Lewin (1910) was able to culture certain amiconucleate fragments of *P. caudatum* in which part of the macronucleus remained. The resulting clones had a low division rate, possibly due to the absence of the micronucleus. Schwartz (1934) confirmed this observation in a brief report; he found that an amiconucleate race divided subnormally for two months before succumbing. A recent personal

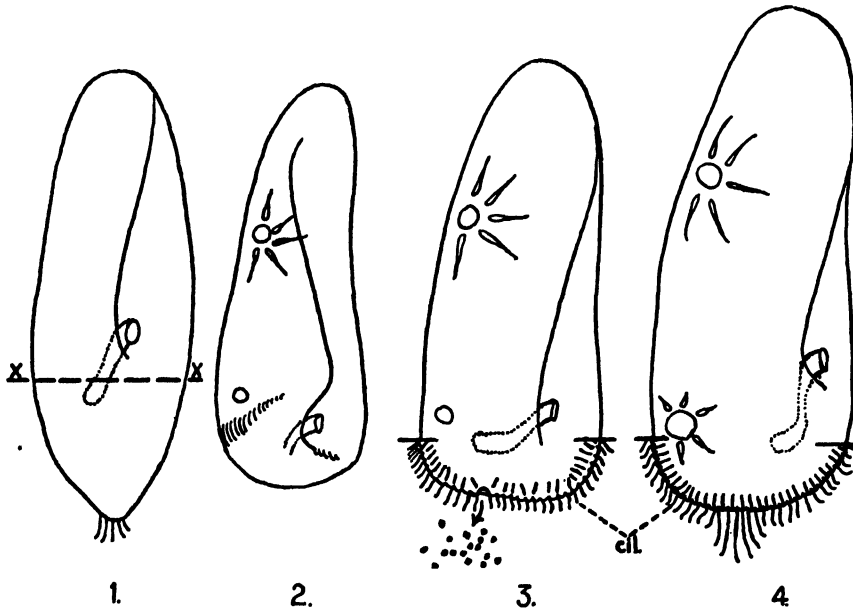


FIG. 4. EARLY STAGES IN THE REGENERATION OF THE POSTERIOR END OF A HOLOTRICHOUS CILIATE, *PARAMECIUM MULTIMICRONUCLEATUM*

1. Level of cut, not showing the intact nuclei. 2-4. Appearance of merozoön 2, 5 and 19 hours after cutting. Note the gradual increase in size during regeneration. x = plane of transection; cil. = regenerating cilium. (After Tartar, 1938a, redrawn.)

indicates, *Paramecium* does not constitute a unique case among ciliates, as had been claimed by some, but rather it belongs to a group in which the factor of healing segregates a large class of individuals at the outset.

The nuclear apparatus of *P. caudatum* consists of a centrally located, oval macronucleus and a single micronucleus. Accordingly, only middle portions of the body contain nuclear material, and this

communication from Schwartz (March, 1939) indicates that he has been able also to produce amiconucleate *P. bursaria*, which are "bisher ganz gut lebensfähig." One is led to infer that the macronucleus alone is essential for regeneration, disregarding the factors essential for viability.

Other Holotrichida have been studied in less detail. In a closely related genus, *Tillina magna*, Gregory (1909) noted only

a fair regenerative ability, although the rapid reconstitution required only 24 hours. Balbiani contributed, in all, studies on regeneration of 14 ciliates. In his earliest work in this connection (1888), using the prostomatous *Prorodon* (= *Pseudoprorodon*) *niveus*, he showed that only nucleate fragments regenerated, completing the process within 3 hours. He noted that the cut surfaces of enucleate merozoa never truly healed; the formation of contractile vacuoles in these fragments was explained as a purely physical process, due to local dilatation in one of the remaining radiating canals. Bütschli (1887-89) recorded an interesting observation by Blochmann on *Prorodon* sp. Under the impact of pressure, the entire pellicular layer together with the cilia separated from the body and were quickly replaced by regenerated structures. In the related *Prorodon* *teres*, MacDougall (1925) contributed a few experiments indicating that small anterior pieces (presumably enucleate) do not regenerate, while posterior nucleate pieces regenerated completely in 24 hours. Verworn's results on *Lacrymaria olor* (1888) and Lepsi's short account of "*Amphileptus incurvatus*" (?) (1926) confirmed the occurrence of regeneration only in nucleate merozoa.

Moody (1912) briefly described regeneration of *Spathidium* "*spathula*" (= sp.) during the interdivisional period. Her few results supported Calkins' work on *Uronychia* (see below), since individuals approaching fission were shown to have the greatest regenerative capacity. Moore (1924) operated on *S. spatula* during various phases of its life-history. Vegetative individuals dedifferentiated completely and then regenerated rapidly, but subsequent fission was delayed until a general restorative growth had occurred.

Holmes (1907) approached the problem of regeneration in *Loxophyllum meleagris*

by studying the rôle of cytoplasmic movements in merozoa. His results indicated that their rôle was subordinate to the actual differentiation of new structures, consisting chiefly in "pulling the body into shape" after missing organelles had been restored.

In a related form, *Dileptus anser*, Balbiani (1893) discovered an extremely well-developed regenerative capacity, possibly correlated with the presence of many macronuclei; four fragments of one individual regenerated within four hours. Sokoloff's results (1924) confirmed these findings. He referred to regeneration in enucleate fragments, but his data show that he failed to distinguish between regeneration and regulation. Vápeník's study (1927) of the effect of repeated merotomy on the speed of regeneration cannot be considered complete, since *D. anser* did not survive more than five operations within ten days (cf. Dembowska, 1925, on *Stylonychia*: repeated regeneration of an individual undergoing 50-60 consecutive operations; also see below). Vápeník's data showed at most that complete regeneration occurred more rapidly after the second and third operations than after the first.

Trachelius ovum was shown by Balbiani (1888) to regenerate only after transection. Hamburger (1903) demonstrated, however, that careful technique ensured successful operations of all kinds, as in *Dileptus*.

Gruber's few experiments on *Loxodes rostrum* (1886) were negative, since merozoa did not survive merotomy. Balbiani's technique (1893) proved more suitable, and regeneration occurred as a rule, although it required at least four or five days. As in *Paramecium*, the restoration of missing structures appeared to take place directly at the cut surfaces (Fig. 5).

Experiments with the oral membrane-

bearing Hymenostomina have contributed few satisfactory data. *Frontonia leucas* regenerated poorly in Gruber's few experiments (1886), deformities being retained for a long time. Balbiani's account (1888) added little to this. Transected nucleate fragments regenerated in 24-48 hours if at all, poor healing properties explaining the frequent failure to recover. Sokoloff's similar results (1924) added the

cessive regeneration, death occurring finally after five operations. Brief accounts of related forms include Prowazek's record (1901) that nucleate merozoa of *Glaucoma scintillans* regenerated, and Balbiani's few negative observations on *Colpidium colpoda* (1893), in which there was apparently no regeneration.

In these studies of holotrichous ciliates, there has been no evidence of a localized

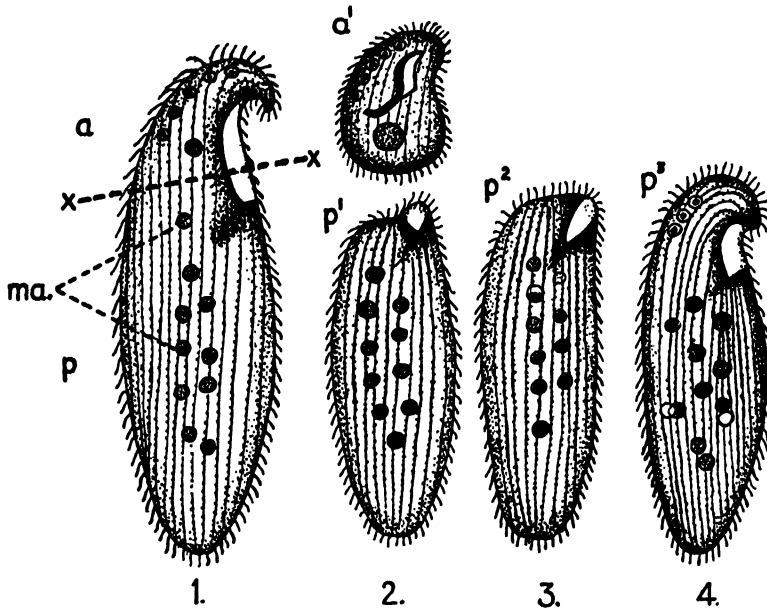


FIG. 5. THE COURSE OF REGENERATION OF THE ANTERIOR END OF A HOLOTRICHOUS CILIATE, *LOXODES ROSTRUM*

1. Level of cut (through oral region), showing scattered macronuclei and five Müller's vesicles. 2-4. Restorative process in anterior (a') and posterior (p^1 - p^2) merozoa, illustrating the direct manner of replacement. x x = plane of transection; ma = macronuclei. (After Balbiani, 1893, redrawn and slightly modified.)

observation that nuclei were readily extruded from merozoa, thereby preventing regeneration. Hartmann (1922) obtained wholly negative results in his experiments on *Frontonia* sp., since merozoa failed to survive merotomy. Popoff's study (1908) of the influence of the nucleoplasmic ratio on division included cutting experiments on *F. leucas*. Repeated operations following regeneration (process not analyzed) caused a delay in each suc-

cessive regenerative potency, nor does any region of the body seem to act as an organizing center for new oral and locomotor structures. Instead missing parts are formed *in situ* at rates depending on experimental conditions. Concerning the relative rôles of macronucleus and micronucleus, the work of Lewin and Schwartz makes it seem probable that the macronucleus alone is essential for the regeneration of missing structures. Whether such ami-

cronucleate individuals can produce viable races, however, is not yet proved.

Turning now to the more complex Spirotrichida, some interesting points of comparison are offered. Of the heterotrichous types, those possessing both cilia and derived organelles, the genus *Stentor* has been analyzed most completely. Its large size, pronounced polarity and multinucleate structure have made it a peculiarly favorable subject.

The inaugural work of Gruber (1885a and b; 1886) showed that *Stentor* regenerated readily after merotomy. He noted that excision of a portion of the adoral zone resulted in a fundamental reorganization; this involved the formation along the left side of the body of a longitudinal anlage which subsequently migrated to replace the remnant of the old adoral zone. This process was noticeably similar to normal fission, replacement being substituted for formation of a duplicate organization (Fig. 6). Reversing his earlier opinion (1885a), Gruber (1885b, etc.) came to the conclusion that nuclear material must be present for regeneration in vegetative individuals.

Further studies have added many data to each of these three important aspects of regeneration. Some general investigations include Lillie's observation (1896) that in *S. coeruleus* and *S. polymorphus* (used interchangeably) complete regeneration occurred only in nucleate fragments containing at least $\frac{1}{4}$ of the original body mass. Morgan (1901b) produced still smaller viable merozoa of *S. coeruleus* ($\frac{1}{8}$ of the original mass), but pointed out the variables which weaken such an approach to the general problem of regeneration. His careful analysis of regenerating fragments showed that a precise mechanism adjusted the size of cytoplasmic organelles to conform with a newly acquired body size, whether this

involved regulation of old or formation of new structures.

Schuberg's study of fission in *S. coeruleus* (1890) gave the first adequate account of that process. He checked and was able to confirm Gruber's report that a new adoral zone developed similarly in division and regeneration. Balbiani (1892) seems to have failed to witness the earlier stages of the migrating adoral anlagen in posterior merozoa, since he refers to their antero-dorsal origin in such fragments (p. 396). Morgan (1901b) and Stevens (1903a) contributed further analyses of regenerating adoral zones and of the regulation of form. Stevens noted in greater detail than other workers the regeneration of longitudinal myonemes and the rôle of cytoplasmic movements in peristome formation. Stevens' paper and that of Ishikawa (1912) described the regeneration of membranelles *in situ* between the cut ends of an adoral zone, but their evidence was not convincing. If these reports were true, it would mean that membranelles could regenerate by two entirely different methods, which would be unusual. It is noteworthy that Johnson's experiments (1893) had led him specifically to deny such an occurrence, pointing out the possibility of confusing the normal dorsal cilia with membranelles in contracted, cut individuals. Later researches have supported Johnson's position. Causin (1931) likened restorative regeneration to an "abortive fission"; he found that in both cases new membranelles formed only from a migrating anlage. The most recent work of Schwartz (1935) is also confirmatory. He established without any doubt, moreover, that the anlage replaces only the oral part of the adoral zone in regeneration (see Fig. 6).

The nuclear apparatus of *S. coeruleus* consists of a long beadlike chain of macro-

nuclear segments and a variable number of micronuclei (10-42). Verworn's few experiments (1888) confirmed Gruber's ac-

this point. Balbiani (1893) reached the same conclusion also for *S. polymorphus* and *S. igneus*. Prowazek (1903a), how-

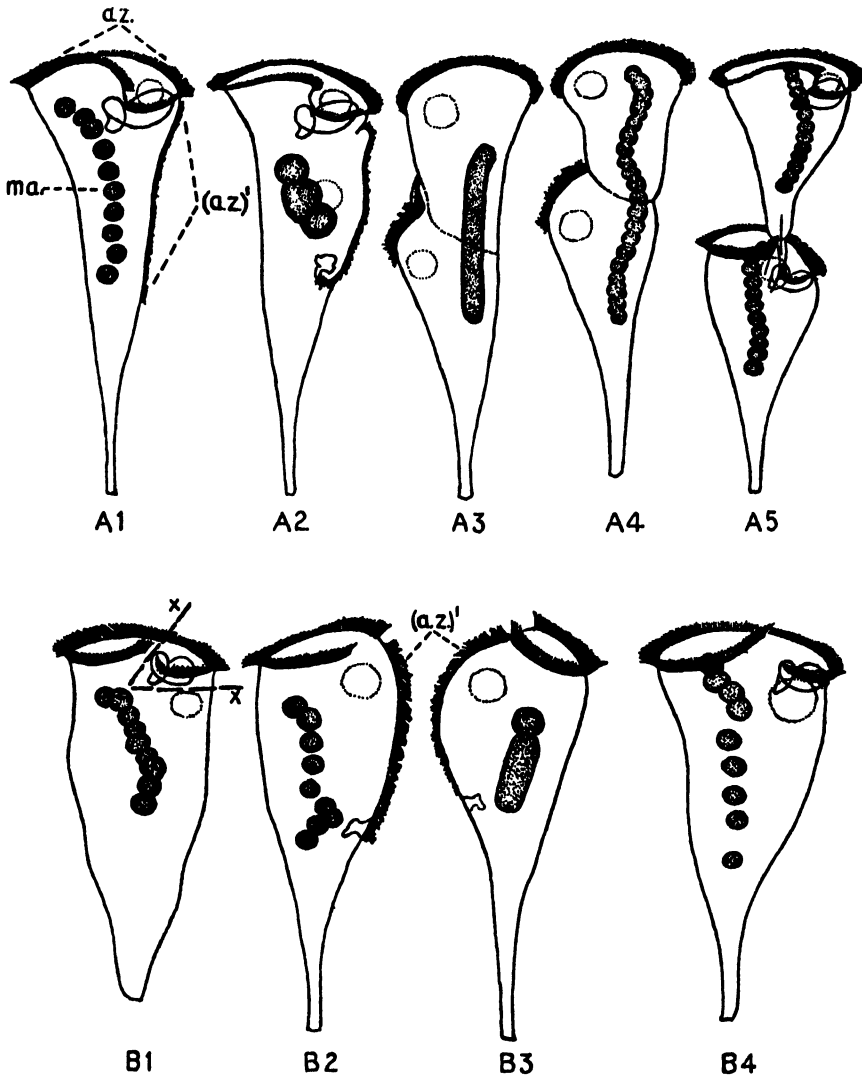


FIG. 6. COMPARISON OF THE COURSE OF FISSION (*A1-A5*) WITH RESTORATIVE REGENERATION (*B1-B4*) IN A HETERO-TRICHOUS CILIATE, *STENTOR COERULEUS*

Note the general similarity in the sites of the oral anlagen and in the behavior of the macronuclei. *a.z.* = parental adoral zone; *(a.z.)'* = anlage of new adoral zone; *ma.* = macronucleus; *x x* = line of excision. (Based on Schwartz, 1935, redrawn and modified.)

count of the necessity for nuclear material in regenerating vegetative individuals, and the great majority of investigators since that time seem to have established

ever, came to a different conclusion. Study of nuclear behavior led him to conclude that repeated injury and culturing at high temperatures resulted in the

regeneration of enucleate fragments; under these conditions "chromidia" given off to the cytoplasm were supposed to have permitted regeneration to occur. His data cannot withstand analysis. In 1913 Prowazek believed to have localized the seat of formative energy in the pellicle and ectoplasm, chiefly because operations removing much pellicle and ectoplasm proved fatal more often than the removal of endoplasm and some nuclear substance. He neglected the simpler explanation that operations of the first kind had so disrupted the regulatory osmotic mechanism as to cause death.

Granting the necessity for nuclear material, it has proved more difficult to determine the relative rôles of macronucleus and micronucleus. Balbiani (1892) emphasized nuclear behavior throughout his experiments. He showed clearly in regenerating *Stentor* that the elongate macronucleus underwent the same contraction ("balling") and re-segmentation as in fission (Fig. 6), being the first to describe this. Balbiani claimed that the macronucleus alone was essential to the regenerative process, but his only evidence was indirect, being derived from the conjugation process. Thus, cutting experiments on individuals in the stage of resorption of the old macronucleus (hence its "non-activity") resulted in no regeneration, while merozoa did regenerate when cut later during the formation of the new macronuclear anlage. Since both macronuclei and micronuclei reorganize simultaneously, however, Balbiani's conclusion favoring the macronucleus obviously is forced.

Schwartz (1934; 1935) was the first to approach the problem directly by attempting to produce amiconucleate and amacronucleate merozoa. By operating on dividing or regenerating individuals in which the macronuclear segments had

"balled" together, he was able to remove the entire macronucleus and still leave from 1 to 16 micronuclei. In these amacronucleate experimentals digestion of food never occurred, nor was regeneration ever induced. In support of Stevens (1903a), however, it was observed that regeneration already in progress before the operation was performed might continue, which indicates the irreversibility of the process after it is once under way. Formation of contractile vacuoles in amacronucleate merozoa is explicable by recalling that they form through a purely physical process (cf. *Pseudoprorodon*, above). To produce amiconucleate individuals, Schwartz repeatedly removed a portion of the macronucleus together with a varying number of adjoining micronuclei. After each operation the remaining micronuclei divided only once; finally (after five operations) cytological examination of descendants of his experimentals showed that all the micronuclei had been removed. No differences in size or division rate could be noted between his two successfully cultured amiconucleate clones and normal controls. One of these clones propagated more than a year before its accidental elimination. If his data are correct, Schwartz's experiments constitute the first clear-cut demonstration of the relative rôles of the two nuclear elements in regenerating heterotrichs.

The relation of nuclear to body size in *Stentor coerules* has been studied by a few investigators. Popoff (1909) claimed that removal of most of the macronucleus caused such an abnormal shift in the nucleo-plasmic ratio as to result in death. Burnside's results (1929) contradict these data (as do also those of Schwartz (1935); etc.). Furthermore, the size of a biotype has never been changed experimentally by merotomy, contrary to Popoff's report.

The importance of the nucleo-plasmic ratio in cell division and regeneration has long been maintained by the R. Hertwig school. This problem cannot be discussed at length here, but it seems clear that at best the nucleo-plasmic ratio can comprise only part of a complex set of factors at work.

The results obtained in studies of several other heterotrichous ciliates seem to fit into the general scheme discussed above. Gruber's paper (1886) stated that *Climacostomum virens* regenerated lost parts within 24 hours. Balbiani (1893) reported a remarkable viability in *Fabrea salina*, nucleate merozoa regenerating readily. In a recent contribution by Tartar (1938b) on *Condyllostoma* sp. (*magnum* ?), there was reported an effect by the amount of nuclear substance in regenerating individuals. Merozoa containing equivalent portions of cytoplasm but more macro-nuclear substance (in the ratio of two or three to one) regenerated on the average twice as rapidly as their sister-merozoa. This difference in speed was due to a difference in the "preparatory" period prior to regeneration (period of "labile equilibrium" of Sokoloff), since the actual time of differentiation after the first appearance of the regenerating anlage was the same in each instance.

Spirostomum has been studied by various workers. Gruber (1886) attributed his lack of success in experiments on *S.* sp. (*ambiguum* ?) to its poor viability in cultures. Balbiani (1888) apparently encountered less difficulty with *S. ambiguum*. Nucleate fragments regenerated within three hours, and contractile vacuoles formed even in enucleate merozoa. Sokoloff (1924) also found a well-developed regenerative capacity, particularly in the middle-third of the body. At the same time he confirmed reports of *Spirostomum*'s sensitivity to environmental conditions.

In 1936 Seyd investigated regulative processes accompanying regeneration. A definite regulative agency appeared to be at work, since disproportionately situated peristomes dedifferentiated and new ones formed at the normal body level.

Blepharisma has an adoral zone whose longitudinal orientation is characteristic of the more primitive heterotrichs. Moore (1924) claimed that no reorganization of remnants of an old adoral zone occurred in mutilated *B. undulans*. Depending on the degree of injury, either new elements were added directly at a cut surface, or after complete removal a new zone formed in the customary place. Since her comparative study of the holotrichous *Spathidium* (see above) had shown that regeneration in that form was always preceded by a dedifferentiation of an old mouth remnant, she concluded in this instance that "... no correlation is apparent between the degree of specialization of external organelles and the method of restitution" (p. 306). She also advanced the corollary that "... reversibility of organization is more limited in certain Protozoa than in others, but complexity of structure is not the controlling factor" (p. 307). One is inclined to question the validity of this conclusion from the available data, particularly in view of the cytological study by Calkins (1912). He found that dividing *B. undulans* replaced the parent adoral zone *in situ* at the anterolateral end of the body (cf. the site of the anlage in *Stentor*, etc.). Since there is a continuous functioning in the adoral zone throughout the division process, it seems only natural to consider the possibility that Moore failed to detect the gradual replacement of a portion of the old adoral zone in regeneration. In a different connection, Nadler (1929) tested the effects on *B. undulans* of certain chemicals, including strychnine sulphate; he

found that they caused shedding of the pellicle without affecting its subsequent regeneration upon return of normal conditions.

The complex, tunneled peristome of *Bursaria truncatella* provides favorable material for studies of regeneration. Lund's investigation (1917) revealed that the peristome is reorganized during fission and regeneration, being more completely dedifferentiated in the latter process. No nuclear changes were observed during these cytoplasmic phenomena. Lund likened the mechanism of dedifferentiation to the purely chemical process of autolysis; thus release of a proteolytic agent could be conceived to cause the breakdown of differentiated structures prior to their subsequent reorganization.

Hartmann's experiments on *Bursaria* proved inconclusive, since merozoa reacted to cutting by encystation. Sokoloff (1924) probed the general regenerative capacity of *B. truncatella* and found that relatively small nucleate merozoa ($1/42$ of body size) could reconstitute a complete organism. His data involving the reputed regenerative ability of enucleate fragments, however, were not convincing (cf. Prowazek, above). Schmähl's comparative study of division and regeneration (1926) corroborated the substance of Lund's work. Like Sokoloff, he noted a direct correlation between the size of a fragment and the time required for its regeneration. Reorganization never followed excisions that failed to injure the peristome or macronucleus; but where reorganization did occur Schmähl believed it probable that the entire ciliary coat also was replaced (which he had demonstrated in dividing forms). Joff (1923) investigated the rôle of mitochondria in regeneration. He discovered that rod-like bodies (demonstrated by Benda's technique) accumulated at the site of injury during

regeneration; and the granular chromatin of the macronucleus became oriented in the same direction. Additional work would be welcomed to corroborate and extend his incomplete observations.

Licnophora is one of the most highly organized ciliates. Found only as commensals attached to various marine hosts, members of this genus are differentiated into a membrane-bearing basal disc, an erect oral disc with an adoral zone, and a supple intermediate region that serves as a neck. The nuclear apparatus includes a single basal micronucleus and a string of macronuclear beads. In her comparative cytological study, Stevens (1903b) included some regeneration experiments on *L. auerbachii*. Restoration occurred only when the basal disc, the neck, a small remnant of the oral disc and both kinds of nuclear material were present. Such regeneration included the newformation of membranelles or of a new adoral zone and mouth, depending on the extent of removal, but no evidence was given of their formation by a differentiating anlage. Instead missing parts apparently were formed *in situ*. Isolated oral and basal discs never regenerated although they survived for several days.

Balamuth (1939) reinvestigated *Licnophora* with a view toward explaining this anomalous behavior. Protozoologists had disagreed about its peritrichous and spirotrichous affinities since 1867. Study both of the structure and regenerative response of *L. macfarlandi* confirmed the view that this genus is a highly modified member of the Heterotrichina. Thus in contrast to Stevens' account, new oral membranelles were derived only from a migrating anlage which formed at the left anterior side of the body as in fission (Fig. 7). Its general regenerative capacity, moreover, was shown to be greater than formerly believed, since isolated,

amicronucleate oral discs definitely could regenerate injured adoral zones. This Missing basal discs were not regenerated,

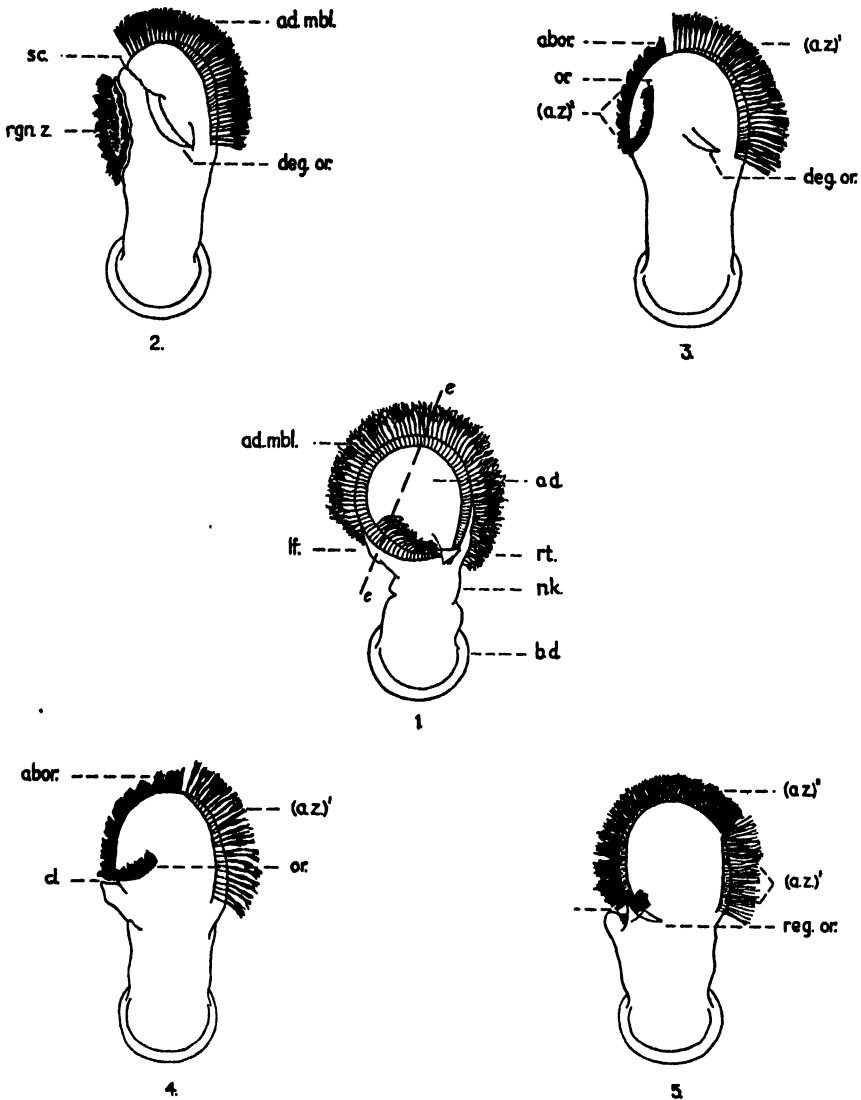


FIG. 7. REGENERATION IN *LICHOPIHORA MACFARLANDI* FOLLOWING EXCISION OF THE LEFT SIDE OF THE ADORAL ZONE (DORSAL VIEW)

Some stages in the regeneration of an injured adoral zone, showing the establishment of a reorganization zone as in fission followed by its migration to replace most of the original zone. In its differentiation the new zone shifts from a dorsal to a ventral position. Nuclear changes are not shown in this figure, but are similar to those in *Stentor*. $e \dots e$ = line of excision; *abor.* = aboral end of new adoral zone; *ad. mbl.* = membranelles of adoral zone; $(a.z.)'$ = original adoral zone; $(a.z.)''$ = new adoral zone; *cl.* = lateral cleft; *or.* = oral end of new adoral zone; *rgn. z.* = reorganization zone; *sc.* = scar left by excision. (Original.)

confirmed Schwartz's discovery for *Stentor* but it was pointed out that the two daughter basal discs form in this genus only

by the constriction of a parent structure undergoing fission. If we adopt the view (as suggested by available data) that the regenerative capacity involves at most a realization of developmental potentialities, then the new findings for *Licnophora* become consistent with other data.

The Heterotrichina are clearly related to more primitive holotrichous forms. Even their adoral membranelles reveal a holotrichous ancestry, for these composite structures develop from groups of cilia in the stage of anlage differentiation. The Hypotrichina bear somewhat the same relation to the Heterotrichina. In these forms the primitive ventral ciliation (still retained in heterotrichs) is replaced by more specialized structures: cirri and membranelles. These localized organelles have enabled investigators to follow the process of regeneration in particularly great detail, and thereby to contribute some of the most important studies of experimental reorganization.

To Nussbaum (1884; 1886) belongs the credit for being the first to conduct systematic regeneration experiments on any Spirotrichida. Using *Gastrostyla* (?) *vorax* his limited data showed that only nucleate merozoa could regenerate: "It seems that the nucleus is indispensable for the maintenance of the formative energy of a cell" (p. 262).

The genus *Stylonychia* has proved favorable for experimental work. Dujardin's incidental opinion (1841) that mutilated *S. pustulata* could regenerate (see Section II, above) was corroborated by Prowazek (1898), who found that nuclear substance was necessary. The same author (1903b) referred to reorganization during "depression" in a related species, *S. mytilus*. He observed only some of the more obvious changes at the posterior end of the body. Dembowska (1925) used *S. mytilus* in her detailed comparison of fission (after Wal-

lengren, 1901) with regeneration. She found a remarkably well-developed regenerative capacity, which included the complete reorganization of all somatic organelles whenever merotomy effected the removal of one or more of these. This restorative process was introduced at the left of the more anterior set of nuclei (except when only one set of nuclei was present in the merozoön) by the formation of an anlage containing in miniature a full complement of the 18 ventral cirri (Fig. 8, 1-3). Together with similar anlagen of a new adoral zone and of two rows of marginal cirri, these rudiments proceeded to migrate to their definitive positions; at the same time all old organelles were being resorbed at a proportionate rate (Fig. 8, 4-6). This restorative process closely simulated the reorganization accompanying fission. Having noted that only complete removal of a cirrus (including the basal plate) provided a sufficient stimulus for regeneration, Dembowska was led to conclude that regeneration in this species must be due to a disturbance in coördination of the locomotor organelles. Since the two kinds of nuclear material could not be separated, her observations on the rôle of the nuclear apparatus were limited to noting that regeneration occurred only in nucleate merozoa.

Young's study of the nuclear apparatus of *S. mytilus* during regeneration (1926) showed that the restoration of missing nuclei proceeded *pari passu* with cytoplasmic reorganization. He concluded that the nuclear complex has a constant species-character. Years previously Lewin (1911) had noted the tendency of micronuclei of *S. mytilus* to increase beyond the normal number during regeneration, while he apparently failed to see a reorganization zone; thus he stated, "... any reorganization ... goes on by im-

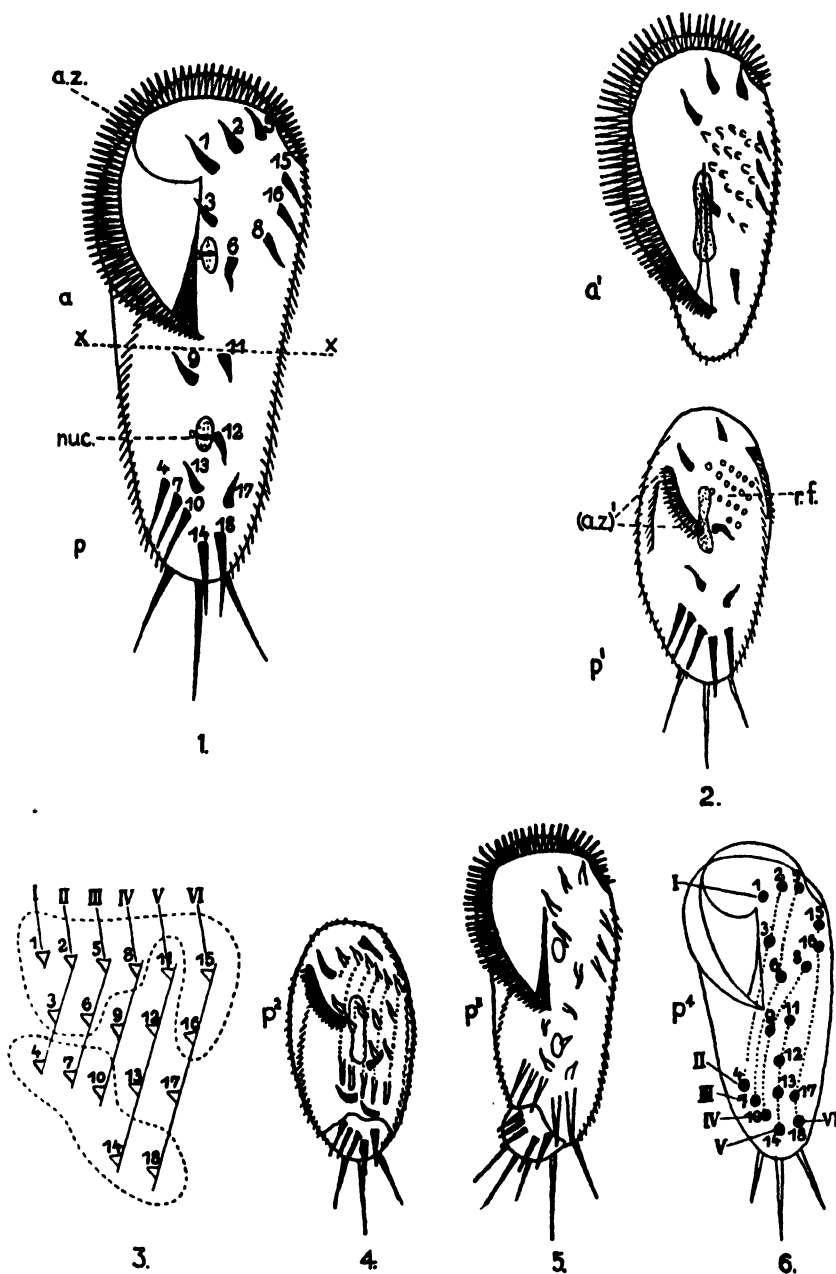


FIG. 8. STAGES IN THE REGENERATION OF A HYPOTRICHOUS CILIATE, *STYLONYCHIA MYTILUS*

1. Level of cut, showing two sets of nuclei. 2. Appearance of anlagen in reorganization fields of anterior (a) and posterior (p) merozoa. 3. Diagram of reorganization field, enlarged. 4-5. Stages in the migration of the anlagen to their definitive positions in a posterior merozoön (p^+). 6. Reorganized individual (p^+) showing path of migrating cirri. $x \dots x$ = plane of transection; $a.z.$ = adoral zone; ($a.z.$) = anlage of new adoral zone; $nuc.$ = posterior macronucleus and micronucleus; $r.f.$ = reorganization field. (After Dembowska, 1925, rearranged.)

perceptible stages." (p. 341). Hewitt (1914) had failed to confirm this nuclear behavior in *Pleurotricha* sp., but his data indicate that he may have neglected to examine regenerating individuals at a sufficiently advanced stage. Newer evidence from several ciliates has shown that there is often a multiplication of micronuclei during the regenerative process, but apparently the normal number is restored before the next fission. Tittler (1938), for example, produced merozoa of *Uroleptus mobilis* by the disintegrative action of induced electric currents, as Verworn (1889) previously had done for many Protozoa. He noted that the micronuclei of regenerating fragments often multiplied beyond the normal number, but the extra ones apparently were resorbed before division occurred. It should be noted in this connection that no investigator ever has confirmed Le Dantec's poorly supported opinion (1897) that micronuclei could be reconstructed from macronuclear substance. His material included several unnamed ciliates, each *presumably* containing only one micronucleus, which he cut into two macronuclear fragments. The subsequent finding of a micronucleus in each merozoön led him to conclude that "... in certain cases at least, the micronucleus is regenerated in merozoa not containing any trace of the old." (p. 51).

Dembowska (1926) compared the regenerative capacity of several other hypotrichs with that of *Stylonychia*. *Diophrys* sp. responded equally well to merotomy, even small nucleate pieces regenerating completely. In so far as some unsystematic experiments on *Amphisia* (?) sp. and *Actinotricha* sp. permitted a conclusion, they seemed to react similarly to *Stylonychia*.

Euplotes has been studied in many connections, some of which have contributed

data to the problem of regeneration. Taylor (1920) made incidental references to regeneration in his cutting experiments on the fibrillar system of *E. patella*. Taylor (1923) and Taylor and Farber (1924) removed the micronucleus from *E. patella*, using a micro-pipette. Such amiconucleate individuals evidently suffered from a waning vitality, since all experimentals (50) died within a few days without dividing more than twice. Regarding the rôle to be ascribed to the micronucleus in cellular activity, Taylor and Farber indicated that "... the conclusion is inevitable that the micronucleus possesses more than a germinal function in the life of this organism" (p. 139).

Dembowska's experiments on *E. charon* and *E. vannus* (1926) simply confirmed the essential points of her above work. Compared to other forms, regeneration in *Euplotes* was noticeably slower. Reynolds (1932) used *E. patella* for cutting experiments. She noted a definite racial variation; thus in one race tentatively identified as *E. patella*, operated individuals regularly disintegrated soon after cutting, while in a second race regeneration occurred only in anterior merozoa containing the micronucleus, part of the macronucleus and sufficient cytoplasm. Amiconucleate individuals always died, regardless of their size.

The same work of Reynolds (1932) included data on *Oxytricha fallax*. This species proved especially interesting, since she used normal and amiconucleate races. The normal, micronucleate race responded like the closely related *Stylonychia* (see above). All the regenerating merozoa contained both macronuclear and micronuclear substance. In the amiconucleate race, however, viable merozoa contained only macronuclear substance, and these too regenerated completely. Reynolds was drawn to the conclusion

that the nuclear content of normal, amiconucleate individuals differed from that of amiconucleate individuals produced experimentally. This might be explained by adopting Woodruff's view that the "macronucleus" of amiconucleate ciliates actually may be an amphinucleus; thus both nuclear elements would be included within a common mass functioning in a dual trophic and germinal capacity.

Calkins (1911a) made the interesting discovery in *Uronychia transfuga* that the regenerative capacity is a function of the interdivisional age. During regeneration the adoral zone and powerfully developed cirri of this complex form were completely reorganized, in the manner described for fission by Wallengren (1901). Cuts made at spaced intervals between division periods separated two kinds of fragments; both contained part of the elongate macronucleus, but only one (depending on the kind of cut) contained the small micronucleus. Of those individuals cut soon after division (up to one hour), only merozoa containing both nuclear elements regenerated, but even these varied in their capacity. In older individuals (about halfway between division periods), the regenerative capacity proved considerably better; not only did merozoa containing both nuclei regenerate, but also amiconucleate fragments were reorganized normally so long as macronuclear substance was present. Thus the regenerative capacity was indicated to be greatest at an advanced interdivisional age, when only the macronucleus was necessary for complete regeneration. Conversely this capacity became reduced immediately after division. The inference was that something not present in the cytoplasm of a newly divided individual became replenished under nuclear influence as maturity was reached.

Young's study of *U. setigera* (1922) fully corroborated Calkins' findings. He noted that regeneration did not follow the cutting of cirri so long as their basal plates were not injured; this pointed again to disturbance in coördination of locomotor organelles as a possible impulse to regeneration. Young strengthened Calkins' results still further by showing for *U. binucleata* that regular regeneration both of anterior and posterior merozoa was correlated with the normal presence of a micronucleus in each part of the body (hence *binucleata*). He concluded that although regeneration definitely occurs at times without the micronucleus, "The ability to grow and divide is dependent on the presence of a micronucleus" (p. 388).

The Hypotrichina display great variation in the place of origin of reorganization zones during asexual reproduction. In *Stylonychia* two distinct reorganization fields appear, one anteriorly and one posteriorly. In *Uronychia* one "compound" field suffices for both daughter individuals. *Diophrys* discloses an additional variation, in that two reorganization fields arise close together posteriorly. Indeed, the one permissible generalization rests in the essential similarity between the course of fission and of regeneration in a given genus. Dembowska's comparative study of *U. transfuga* and *U. setigera* (1926) emphasized once again this general similarity.

Taylor's thorough study of *U. uncinata* (1928) corroborated the essential points in previous work. Taylor presented an interesting theory of protoplasmic reorganization, emphasizing the similarities between normal, cyclical reorganization and the course of regeneration. According to this theory, all protoplasmic reorganization would involve essentially a dispersion (dedifferentiation) followed by

a recondensation (redifferentiation) of the molecular components of cellular structures. Accompanying this profound resynthesis there might well occur a "physiological rejuvenescence" in the sense of Child. Consequently, the effect of reorganization in general can be visualized in terms of a heightened physiological activity. A favorable feature of this hypothesis is that it is susceptible to a precise experimental approach; also it takes cognizance of an underlying similarity between fission and regeneration.

It is obviously desirable to correlate morphological and physiological data in seeking evidence of "rejuvenescence," "aging," etc. Bauer and Granowskaja (1934a and b) have made a pioneer attempt in this direction for Protozoa, using *Oxytricha* sp. and *Gastrostyla* sp. It is interesting to compare their theory of protoplasmic reorganization with that proposed by Taylor. Their starting-point is a thermodynamic concept of the cause of rejuvenescence. Briefly, it postulates that the onset of cellular reorganization is dependent upon attaining a "growth-limit." The latter is restricted in turn by the amount of free energy per unit mass available for further assimilation, and growth will cease when the mean free energy begins to decrease. In order to restore the potentiality for further growth, a decrease in the biological system (*i.e.*, cell division) must occur and liberate additional energy. In other words, normal reorganization (cell division) will occur only when the capacity for further assimilation reaches a certain limiting threshold. At this point cell division ordinarily serves the dual function of diminishing the biological mass and, in some unknown manner, of liberating additional energy to be used in further growth. The advantage of this theory is to provide a cause for reorganization and

to show how the end-result satisfies the impelling cause. To apply this theory to protozoan regeneration, they argued as follows: Since the immediate impulse to rejuvenescence apparently is a natural decrease of mass, experimental removal of part of the body (merotomy) might be able to replace fission as a rejuvenating stimulus.

Their first paper (1934a) sought to discover whether the nuclear changes and respiratory rate of operated individuals indicated that a rejuvenating process was actually at work. On the whole, the results supported their hypothesis. Thus they showed that adult and young individuals reacted differently to merotomy; only the former (*i.e.*, individuals having reached the "growth-limit") showed evidences of experimental rejuvenescence. These underwent a complete macronuclear reconstruction that was accompanied by an intensified respiratory rate (measured by a Kalmus respirometer). Young individuals, on the other hand, did not undergo nuclear reconstruction, but instead exhibited a lower respiratory rate.

In their second paper (1934b), these investigators used a different approach. Hartmann had claimed that repeated regeneration could be substituted indefinitely for fission, as a result of experimenting on *Stentor coerules* (1922) and on two species of *Amoeba* (1924; 1928; also see *Sarcodina*, above). Bauer and Granowskaja showed that this held true only when the age factor discovered above was recognized. Consecutive operations on individuals which had reached their maximum size resulted each time in complete reorganization, and hence raised the possibility of the indefinite existence of a protozoön as one undivided individual. Their most successful experimental was still alive after 28 days (*cf.* 52 days for *S. coerules* and 4 months for *A. proteus* in

Hartmann's experiments). Repeated operations on young individuals resulted inevitably in their death. Bauer and Granowskaja concluded that experimental "individual immortality" (Hartmann) is the result of the same physiological reconstruction processes which occur at periods of division. Merotomy apparently disturbs the fission normally associated with these processes and substitutes instead the regeneration of the original system.

These data may aid in explaining the previously recorded behavior of *Uronychia* and *Oxytricha*. In both these forms only adult merozoa could regenerate consistently, while younger stages usually failed to do so, especially in the amiconucleate condition. The work of the Russian investigators indicates that younger stages of some Hypotrichina may be quite different in their general physiological potentialities from later periods, as indicated, for example, by a different respiratory rate and morphologically expressed nuclear inactivity. A slighter capacity to regenerate may be one expression of this difference. Future investigations should be designed to corroborate these data and test the possibility of extending this approach to other phases of cellular activity.

In concluding this account of the Holotrichida and Spirotrichida, it seems clear that an increasing order of complexity is accompanied by a more regular pattern of regeneration. The well-defined anlage of the adoral zone of heterotrichs is succeeded in hypotrichs by localized anlagen for nearly all ciliary organelles. Now, it happens that recent anatomical studies of even the least specialized ciliates, the holotrichs, indicate that a precise cytoplasmic mechanism equivalent to anlage formation also operates in those forms, at least during fission. Chatton and his

collaborators have established in various genera undergoing fission that the newly forming mouth regions are in genetic continuity with the parental structure. This is caused by the proliferation of new basal granules and connecting fibrils either from a central primary stomatogenous fibril (*cinétie stomatogène*) or from a more diffuse ciliary field, the details varying.

It is instructive in this connection to turn to the one group of ciliates still to be treated here, the Peritrichida. The structure of these forms indicates a derivation from generalized holotrichs. This derivation is emphasized by the existence in this group also of a genetic continuity of oral structures (Chatton and Villeneuve, 1937). Indeed, the authors state: "The Peritrichida exhibit . . . the most direct kind of genetic continuity of oral structures that is known to us." Experimental corroboration of these anatomical accounts may be anticipated in the near future.

The Peritrichida have been subjected to few experiments. The most fruitful approach has been used by Summers (1938a and b), on a complex colonial type, *Zoothamnium alternans*. The frond-like shape of this species results from the geometric precision with which its colonial members differentiate. The apical cell (terminal macrozooid) acts as a growing-point, and on each side gives off branches alternately which proliferate laterally. Six types of individuals are produced during the growth cycle of this species. Summers tested the ability of colonies to regenerate following the removal of various parts. The regenerative capacity proved to be well-developed. Thus removal of the terminal macrozooid generally resulted in the assumption of that dominant position by the next lower terminal branch zooid, although in some

instances other individuals became the new growing-point instead. The inference was that removal of the terminal macrozooid disturbed the physiologically dominant region of the colony, so that adjustments were necessary to establish a new relation of dominance-subordination. The consequent shift in morphogenetic expression indicated the labile and reversible nature of the colonial organization. On the whole, regulatory responses were evoked more readily in the younger individuals of the colony.

Summers suggested that time might play an important rôle in determining the reactivity of the different cells, for it was known that protozoan cytoplasm undergoes progressive physiological changes between division periods. Thus "... the intracellular activities of a *Zoothamnium* cell may lead to the "fixation" of specific potencies at some critical period after cell division..." (p. 148). The expression of physiological dominance is also clearly important under normal conditions, since the transformation of the terminal macrozooid into a conjugating macrogamont results in the temporary shift of dominant growth to a sub-adjacent point. *Zoothamnium* presents good evidence, therefore, that regulatory mechanisms exist normally as in some Metazoa, and may act according to the degree of determination of certain cells.

The important rôle of physiological dominance in peritrichs was noted as early as 1914, by Runyan and Torrey. When a solitary vorticellid (e.g., *Vorticella* sp.) undergoes fission, the migratory daughter individual develops an aboral ciliary ring soon after losing contact with the parent stalk. By removing normal individuals from their stalks, they experimentally induced the same response. The presence of a stalk, therefore, appar-

ently inhibits the appearance of aboral cilia.

The relation of physiological dominance and subordination of parts has been disclosed in a series of studies on protozoan regeneration. For example, the onset of regeneration seems to vary inversely with the extent of injury. Thus Morgan (1901b) found that the presence of a portion of the old peristome of *Stentor* inhibited the formation of a new one. Similar observations have been recorded by Moore (1924) for *Spathidium*; by Dembowska (1925) for *Stylonychia*; and by Schmähel (1926), Taylor (1928), etc. Since Child's demonstration (1914) of a metabolic gradient along the antero-posterior axis of ciliates, other investigators have confirmed the fact that the anterior region of the body generally occupies a dominant position. Taylor (1928) and Tittler (1938) have found that anterior merozoa begin to regenerate sooner than posterior merozoa. This might explain Dembowska's observation (1925) that the regenerating anlagen in *Stylonychia* always made their appearance alongside the anterior nuclear complex when it was present. Future study must decide whether the determining factor in such instances is a higher metabolic activity anteriorly.

The only ciliates remaining to be considered are a few endoparasitic forms which have received little attention. Sokoloff (1924) found that *Anoplophrya filum*, a large astomatous holotrich, had a very slight regenerative capacity posteriorly; thus replacement of cilia proved more successful at that end of the body. The opalinid ciliates respond poorly to all experimental treatment since they cannot be cultured successfully outside their amphibian hosts. Nussbaum (1884; 1886) found that fragments of *Opalina ranarum* disintegrated after a few hours without

showing evidence of recovery. Sokoloff (1924) used various salt concentrations in his culture media, but *O. ranarum* never survived longer than 12 hours. He reported the appearance of some cilia at a cut surface, but this irregular response was the only indication of regeneration. In Joff's study of *O. ranarum* (1923), it was shown that rod-like bodies (mitochondria) accumulated at the edge of a wound within an hour after cutting, but he gave no evidence of regeneration. It would seem, therefore, that endoparasitic ciliates do not react like free-living forms. Since satisfactory nutritive media were not provided in these experiments, however, final judgment must still be withheld.

(2). *Regeneration in dividing individuals*

We have seen that ciliates in ordinary vegetative stages possess a remarkable ability to restore missing parts. The question arises, whether or not the regenerative capacity is equally well-developed during other stages of the life cycle, that is, during fission, encystment and conjugation.

Only a few of the many references to merotomy during fission have disclosed important facts. Gruber's few data (1885b) indicated that *Stentor* undergoing fission had the same regenerative capacity as at other times. The work of both Peebles (1912) and Tartar (1939) on *Paramecium caudatum* supported this view. On the other hand, Calkins' study of *Uronychia* (1911a) showed that late division stages reacted relatively poorly to cutting. Where cytoplasmic viscosity decreases during fission, recovery may become more difficult in proportion to the greater danger of diffuence.

There is evidence that a "division zone" is established in ciliates even before the appearance of external signs of fission.

This would explain the fact, first mentioned by Balbiani (1892), that merotomy often does not interrupt the physical cleavage process and may result, therefore, in the production of unequal sized offspring. Fauré-Fremiet's study of *Urostyla grandis* (1910), a large hypotrich, showed that division is a reversible process up to a certain stage. During the earlier period, operated individuals returned to the vegetative condition and regenerated before dividing. Merotomy during the later stages showed that division had become irreversible. The behavior of dividing *Stylonychia* discloses some additional facts. Dembowska (1925) found that merotomy had no effect on the division process, since this continued in all instances studied. Concerning regeneration, she found that removal of parental organelles (organelles destined to be replaced during fission) did not cause a regenerative process to follow division. The excision of any newly forming organelles, however, resulted later in the regeneration of all organelles in the "presumptive" offspring which had been mutilated.

The irreversible nature of the division process leads logically to the problem of whether or not morphogenesis itself can become irreversible during fission. If that should occur, then one might expect new-formation to occur in enucleate dividing merozoa. Gruber (1885b) reported that this actually was the case in amacronucleate dividing *Stentor*, stating "... we are dealing with a movement whose course no longer can be halted, even if the moving force (*i.e.*, the macronucleus) is removed" (p. 140). Stevens (1903a) extended this observation to regenerating individuals, in which an anlage had appeared before she removed the "balled" macronucleus. Balbiani's work (1892) on *Stentor* cast some doubt

on these data, since he showed that new-formation could continue in enucleate dividing merozoa only in late stages ("balling" of the macronucleus); when the macronucleus was removed in earlier stages the anlage did not continue to develop. The interpretation to be derived from this fact is that nuclear material seems to be essential to the formation and maintenance of an anlage until a certain irreversible stage is reached. Following that stage, further development probably involves essentially the unfolding of structures already present as rudiments.

(3). Regeneration in encysting individuals

Encystment occurs at various times in ciliates, in some for protective purposes, in others for endomictic reorganization, and in a few forms during the division process. Where the last occurs (*Stylonethes*, *Colpoda*, etc.), it should prove interesting to learn whether the mode of regeneration is in any way correlated with this. An incidental observation by Garnjobst (1937) did show that *Stylonethes sterkii* regenerated within a cyst after accidental injury. Apparently the same fundamental processes underlie both division and regeneration in this form also.

(4). Regeneration in conjugating individuals

The reorganization of the nuclear apparatus during conjugation raises the question, whether or not changes occur also in regenerative capacity during this period. Balbiani (1892) noted that the ability to regenerate varied with the stage of conjugation. When cut soon after joining in conjugation, *Stentor* regenerated consistently. The nuclear apparatus of these individuals had not begun to reorganize. Later, when the old macronucleus had begun to be resorbed, regeneration did not occur after merotomy. Toward the end of the conjugation process, after the

appearance of the new macronuclear anlagen, cutting again evoked the regenerative response. As indicated in the section on *Ciliata* (see above), this furnished indirect evidence of the importance of the macronucleus during regeneration. Calkins (1921) operated on *Uroleptus mobilis* during various stages of conjugation. He showed that removal of the cytoplasmic bridge containing the migrating gametic nuclei had no effect on the reorganization process. Once under way, nuclear and cytoplasmic reorganization continued in the merozoa without cross-fertilization. Operations on individuals preparing to conjugate, however, were not followed by any similar nuclear reorganization. As in fission, therefore, there seems to be an early stage of labile determination, following which the conjugation process becomes irreversible without regard to the consequences.

(b). Physiological regeneration

All the preceding accounts of regeneration have had at least one element in common, namely, a restoration of structures caused by some kind of injury to the body. Physiological regeneration, on the other hand, involves a process of replacement whose immediate cause may not be noticeable, but which is traced to a normal growth process. Periodic moulting and replacement of worn-out parts fit into this category; and the apparently spontaneous replacement of the oral region of ciliates has also been ascribed to this process. However, the dividing line between physiological regeneration and restorative regeneration in Protozoa cannot be very sharp. The partial fusion of two bodies during conjugation, for example, causes the local resorption of organelles. Maupas (1889) described the ensuing fundamental reorganization of all somatic organelles in several genera of the Hypo-

trichina; Hammond (1937) recently analyzed *Euplotes patella* with particular care. In all reports the reconstitution has been found to simulate the course of experimental restoration.

Are these instances of restorative regeneration or physiological regeneration? The latter presumably results from the operation of a normal internal mechanism, and yet conjugation can be induced experimentally. Many investigators have supported the view that conjugation

regeneration in ciliates is the spontaneous replacement of the adoral zone in free-swimming *Stentor*. Balbiani (1891a) described the process in *S. coerules* (Fig. 9), and showed that the nuclear and cytoplasmic aspects of reorganization were similar to those occurring in fission (cf. Fig. 6). He discovered also that cultural conditions could exercise some effect: "... by placing these animals under certain cultural conditions, ... after some days there are induced numerous regen-

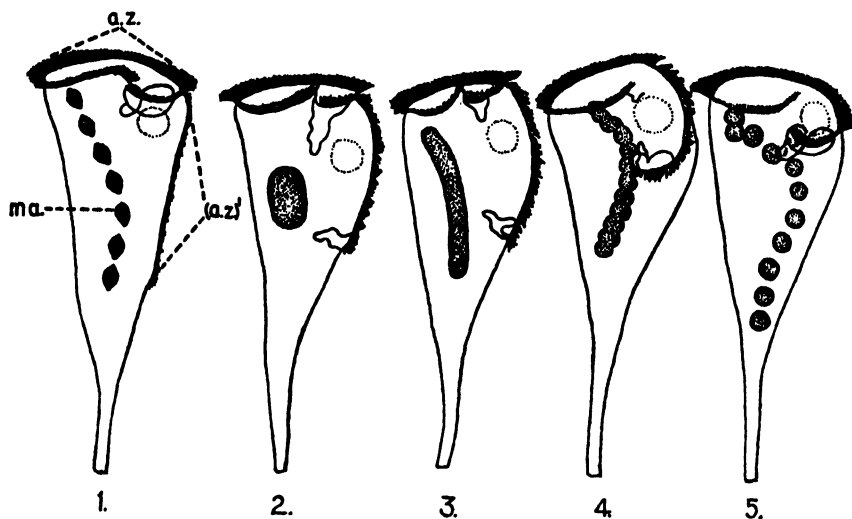


FIG. 9. PHYSIOLOGICAL REGENERATION IN *STENTOR COERULEUS*, SHOWING PROGRESSIVE REORGANIZATION OF THE ADORAL ZONE AND MACRONUCLEUS (cf. FIG. 6)

a.z. = parental adoral zone; (a.z.)' = anlage of new adoral zone; ma. = macronucleus. (After Schwartz, 1935, redrawn and slightly modified.)

induces nuclear and cytoplasmic rejuvenescence. If this is true, then the reorganization of somatic organelles involves their "physiological regeneration." A different view is available, however. Maupas (1889) regarded the cytoplasmic reorganization accompanying conjugation as essentially a kind of restorative regeneration, made necessary by the lesions resulting from the physical act of mating. The available evidence seems to favor this latter view as the more reasonable one.

The classical example of physiological

regeneration, the course of which occurs in a perfectly regular manner" (p. 324).

Physiological regeneration has been recorded for other Protozoa. Johnson (1893) independently confirmed Balbiani's account, using *S. coerules* and *S. polymorphus*. Fauré-Fremiet (1906) described in detail an abnormal individual ("monster") of *S. coerules*, which apparently resulted from abortive physiological regeneration. Schwartz (1934; 1935) described the process in this species most recently. He supported Balbiani's opin-

ion that it represented a normal, periodic growth process.

Other ciliates in which physiological regeneration has been described include *Nassula* (mentioned by Chatton and Lwoff, 1936); *Colpidium campylum* (Klein, 1928); *Glaucoma scintillans* (Chatton, Lwoff, Lwoff and Monod, 1931; von Gelei, 1935); *Bursaria truncatella* (Lund, 1917; Schmähl, 1926); *Licnophora macfarlandi* (Balamuth); *Holosticha rubra* (Wallengren, 1901); and *Cyathodinium piriforme* (Lucas, 1932). *Cyathodinium* is especially interesting because of its unique mode of reorganization; the new ciliature and peristome arise as an intracellular anlage which later migrates to the surface. It is notable that the same kind of reorganization process occurs during fission.

Physiological regeneration has been recorded also in other groups. Cienkowski (1873) noted in *Noctiluca* that "... the flagellum is often gradually resorbed and then regenerated on the rounded-up body" (p. 50). The heliozoan, *Wagnerella borealis*, regularly replaced its capitate upper end after losing it spontaneously (Zülzer, 1909). An equivalent process of restoration has been described even in the parasitic Sporozoa. Léger and Duboscq (1904) found that the gregarines, *Stylorhynchus* and *Pyxinia*, could spontaneously regenerate attachment-organelles (epimerites), depending on the trophic conditions.

Finally, attention should be drawn to an investigation by Hetherington (1932). He questioned whether physiological regeneration was a "normal growth process" in *S. coerules*, since he could find no evidence of its occurrence in controlled culture media. In mass cultures, on the other hand, such reorganization occurred frequently. His conclusion was simply that chemical as well as physical stimuli can induce regeneration. The inference

seems clear that what has been termed "physiological regeneration" may also be a reparative process. This would remove it from its status in a special category.

(5). Influence of environmental factors on regeneration

Environmental conditions exert a definite influence on the course of regeneration. For example, growth processes generally vary directly with the temperature within the biological range. Morgan (1901b) was able to inhibit the regeneration of *S. coerules* for many hours by subjecting merozoa to low temperatures. Later investigators have amplified the general applicability of this fact.

It is well known that the hydrogen-ion concentration sets definite limits to growth capacities and even to viability. Sokoloff (1924) noted that ciliates responded very differently to changes in acidity; thus *Dileptus* regenerated at a pH of 9.2 with little difficulty, while fragments of *Bursaria* did not remain viable at a pH above 8. Chejfec (1932) attempted to increase the regenerative capacity of *Paramecium* by varying the hydrogen-ion concentration. He found that the ciliates survived and regulated better in a more acid medium (pH of 5). Since the viscosity of cytoplasm increases at a lower pH, apparently this is an important factor in accounting for the difference. Tartar has observed that *Paramecium* can be cut more easily in an acidified medium, owing to the changed physical condition of the outer cell-layer.

The effect of the ionic composition of the medium on the regenerative process has not been studied sufficiently. Balbiani's preliminary work (terminated by death) in 1899 showed that a hypertonic solution could have the same effect as merotomy. When *Stylonychia mytilus* was

subjected to a 0.25 per cent solution of "sea salt," various parts of the body underwent gradual dissolution. These mutilations proved readily reversible upon return to normal conditions, although Balbiani failed to detect evidence of an anlage during regeneration. Sokoloff (1924) tested the relative effects of different ions on regeneration. Using several ciliates, he found that in weak concentrations mixtures of Na and Ca ions exercised a stimulating effect on healing and regulation of shape, the Ca ions being most beneficial of those used. This is possibly related to the mechanism in metazoan cells, for Heilbrunn (1934) and others have shown that the Ca ion acts in membrane formation following merotomy (the surface precipitation reaction). Further experimentation along these lines is definitely necessary.

The nutritive condition seems to play an important rôle in reorganization. Wallengren's analysis of *Paramecium caudatum* (1902) showed that inanition induced a series of progressive changes in the cytoplasm and macronucleus. These included resorption of cilia, vacuolization of the endoplasm, structural alteration and fragmentation of the macronucleus. Such changes were reversible up to the point where prolonged starvation finally caused granular degeneration of the cytoplasm. It may be concluded, therefore, that starvation finally produces an irreversible change in cytoplasm that is not comparable to the effect of earlier stages of inanition. Enriques (1912) compared the effects of hunger and "senile degeneration" on the nuclear apparatus of two hypotrichs, *Oparcularia coarctata* and *Stylonychia pustulata*. He found that the macronucleus experienced similar changes in both instances, agreeing with Wallengren's description. These degenerative modifications during hunger were used

as evidence of a visible disturbance in the normal secretory activity of the macronucleus. Lund (1917) noted that starvation caused *Bursaria* to decrease in size from 600 μ to less than 90 μ . Reorganization of these smaller individuals often occurred after two or three days without food. Evidently inanition induces deep-seated changes in protozoan organization.

Several studies of regeneration already referred to have included data involving nutritional factors. Peebles (1912) showed that starvation of *Paramecium* caused a decrease in regenerative capacity. Similar results were obtained by Young (1922) on *Uronychia*, and by Moore (1924) on *Spathidium*. Using *Bursaria*, Sokoloff (1924) found that individuals which had been deprived of food for two days regenerated better than the average, while more advanced deprivation caused the loss of all regenerative ability. Chejfec's study of *Paramecium* (1932) supported Sokoloff's results in showing that mild hunger increased the incidence of recovery and regulation of merozoa. These results agree, in general, with the implications of Wallengren's study.

In this connection the recent work of Dembowska (1938) is especially timely. Having observed that *Stylonychia mytilus* occasionally underwent a complete reorganization without apparent cause, Dembowska investigated the rôle of cultural conditions. She was able to demonstrate that hunger was the causal factor, acting probably through an altered structural organization. Thus by withholding all food during the lifetime of an individual, it underwent a series of repeated reorganization processes quite similar to those occurring in fission and regeneration (cf. Fig. 8). The average response was 26 complete reorganizations during a 19-day period of viability. Reorganization occurred more frequently with advancing

hunger, so that toward the end the ciliates were literally in a condition of permanent reorganization. Both types of nuclei tended to multiply as in fission, but the extra ones were resorbed in each instance before the following reorganization process.

This investigation may account for several reports of apparently spontaneous reorganization which have been referred to the special category of physiological regeneration. It may hold in some of these cases that instead of a periodic growth process, simple environmental factors have acted as causal stimuli. It will be recalled that Balbiani (1891a), Lund (1917) and Hetherington (1932) also noted an effect by the milieu on the onset of "physiological regeneration."

Among environmental factors not usually considered is that of parasitism. Many Protozoa are attacked by parasites, although the true nature of these invaders was not established until after the middle of the nineteenth century. As early as 1876 Bütschli made some interesting observations on parasites of ciliates. In several instances he was able to transfer infections of suctorians from ciliate to ciliate. More to the point, he recorded the complete reorganization of the peristomal region in a *Stentor coerules* which had been parasitized by a holotrich (p. 349). It is possible that some injurious action of the parasite provided the necessary stimulus for reconstitution. Most of the records of parasitism in Protozoa simply describe progressive degeneration of the hosts.

To summarize this phase of the review, it seems that regenerative processes can be induced by other factors besides hunger. Certain environmental stimuli evoke a reorganization comparable to that following physical removal of material. The response always seems to

follow a fundamental course which is roughly analogous to the mechanics of fission. No proof has been offered to show that physiological regeneration does not exist, but in the light of recently exposed facts a reinvestigation of previous reports and further, controlled experiments seem highly desirable.

IV. EVIDENCE BEARING ON THE MECHANISM INVOLVED IN REGENERATION

The descriptive aspects of regeneration have an intrinsic interest, but they leave unsolved the more fundamental problem, namely, the nature of the *mechanism* underlying these remarkable form-changes. In each instance the course of morphogenesis is determined by the degree of organization of given Protozoa. Functional necessities have been met by a wide variety of structural adaptations. In some forms, indeed, there is even a progression of cyclical stages involving complicated metamorphoses (cf. the malarial parasite, or Foraminifera, or certain ciliates). Although this complex organization is contained within a common limiting membrane, it is unsatisfactory to regard a protozoön as equivalent to a metazoan cell. The true point of comparison rests in the organismal nature both of Protozoa and Metazoa. As long ago as 1852 Perty indicated the inadequacy of the *cellular* approach in concluding that "... this *Concept of the Cell* in no way has universal validity; in the lower creatures the organism and the cell (or cells) are identical" (p. 51). In this century Dobell (1911) and others have elaborated upon this thesis of the non-cellularity of Protozoa.

If we regard the Metazoa and Protozoa as comparable groups, then morphogenetic changes during the development of multicellular forms should be reflected by some analogous ontogenetic processes in Pro-

tozoa. Facts already presented support this view. A protozoan individual develops during fission from a relatively homogeneous substratum. Progressive cytoplasmic and nuclear changes occur between reproductive periods; and regenerative potencies, for example, depend on the physiological condition at a given moment. In other words, just as formative processes transform a germ cell into a mature metazoan individual, certain comparable processes act on a developing protozoön. All the available evidence has indicated that the regenerative process follows the same general course as fission. The inference is that regeneration too is essentially a kind of development. Preservation of species-identity emerges as the fundamental problem. Apparently the causal mechanism of reorganization may be stimulated in various ways. Under ordinary circumstances it consists in growth beyond the normal limit; under experimental conditions of regeneration it may include any of a number of physical and chemical disturbances.

The formative process must receive its initial impulse either from the cytoplasm or the nucleus, or possibly from an intimate interaction of the two. Most investigators have been concerned more with the *mechanics* than with the *mechanism* of regeneration, and accordingly have emphasized the more obvious cytoplasmic phases of reorganization. It has been shown, however, that nuclear changes also definitely occur. Some workers have supported the opinion that the cytoplasm is the seat of the formative mechanism, despite the fact that enucleate fragments invariably fail to survive the effects of merotomy. Loeb (1899) reflected one approach used by this group in offering the opinion that "... the nucleus is the oxidative organ of the living substance; ... enucleate cell-fragments are unable to

regenerate only because in them the oxidative activities have sunk to a sub-minimal level" (p. 692). This view would reduce the nucleus to the rank of an essential but subordinate organelle. Loeb was apparently unaware of the fact that Verworn (1892) had shown that enucleate fragments of *Bursaria* also utilized oxygen. Lynch (1919) presented even more effective evidence against Loeb's hypothesis, using *Amoeba proteus*. His data demonstrated that respiration and metabolic rate are not depressed by enucleation. He argued, therefore, that there must be important centers for oxidation in the cytoplasm.

Others, such as Prowazek (1913) and Sokoloff (1924), have supported Loeb's view, consciously or not, in claiming that the nucleus is not always essential for regeneration. As recently as 1929 Klein claimed that the ectoplasm and silver-line system of ciliates represent the site of formative energy. With no direct evidence of his own for support, he asserted: "During regeneration the nucleus remains completely inactive and does not participate in the restorative process" (p. 251).

Evidence favoring the nucleus as the source of regenerative energy has been more abundant, and is derived from various channels. Morphological evidence from fission indicates that nuclear activity often precedes the first cytoplasmic changes. Evidence involving ciliates should prove especially valuable, since trophochromatin and idiochromatin are considered to be segregated in these forms. Summers (1935), Hammond (1937), Young (1939), etc. have shown that macronuclear reorganization begins before cytoplasmic changes in various Spirotrichida. Awerinzew (1916) described the interesting changes accompanying fission in *Lagenophrys*, a cilioid peritrich. Besides noting the absence of observed that the macronucleus or the

migratory daughter individual alone acquired an irregular shape and gave off fragments to the cytoplasm. These evidences of activity were correlated with the fact that only the migratory daughter formed a new attachment apparatus and test. Extrusion of chromatin elements during macronuclear reorganization has been reported in many other ciliates. Although its significance is not yet clear, from a chemical point of view it is plain that this "purification process" (Calkins, 1930) must liberate complex substances into the cytoplasm. In this site they would be available for further use. Another indirect evidence of nuclear activity during morphogenesis is the reference by Bütschli and others to the accumulation of nuclei at the site of shell secretion in Foraminifera (see *Sarcodina*, above). Physiological evidence also indicates that the nucleus (macronucleus in ciliates) is a site of secretory activity. Thus enucleation impairs the healing of cut surfaces, the secretion of sticky substances by locomoting amebae, the digestive function and all anabolic processes.

Regeneration experiments have contributed more direct evidence of nuclear activity during morphogenesis. Early work by Brandt (1877) on *Actinosphaerium* and by Schmitz (1879) on unicellular algae (*Valonia*, etc.) had shown that the nucleus must be present for new-formation. This had provoked the long series of experiments by Nussbaum, Gruber and others on Protozoa. Regeneration is clearly dependent upon the presence of nuclear substance in these organisms. In the ciliates, furthermore, it has been shown that the macronucleus alone controls the onset and maintenance of regeneration (see *Ciliata*, above). Certain facts derived from occasionally abnormal regeneration also have supported these findings. Balbiani (1891b) produced a "double

monster" in *Stentor coeruleus* by incomplete merotomy. He correlated the dual cytoplasmic organization with the dual macronucleus which was also present. When the two sets of macronuclear segments fused to form a single macronucleus, there resulted a striking cytoplasmic rearrangement and the restoration of a unitary organization. Macronuclear activity seems to have been the guiding factor. There are many other instances of monster-formation in Protozoa as a result of abnormal regeneration, but the behavior of the nuclear apparatus has not been followed closely. Rhumbler (1902) distinguished between "multiple-individuals" and "cleft-individuals" in his analysis of foraminiferan monsters. Calkins (1911b) analyzed several extreme cases in *Paramecium* in which a body contained as many as fourteen oral regions. Heteromorphosis has been described in *Bursaria* (Lund, 1917) and in the related *Condylostoma* (Tartar, 1938b). Careful study of nuclear activity is needed in all such instances as these.

Even conceding it an active rôle in morphogenesis, the nucleus might conceivably function merely as an orienting agent for formative substances elaborated in the cytoplasm. There is no evidence, however, that this is the case. On the other hand, it has been shown in various connections that the nucleus may secrete substances into the cytoplasm. A more probable mechanism, therefore, involves the active secretion of stuffs by the nuclear apparatus (macronucleus in ciliates) during periods of morphogenesis.

Difficulties of direct demonstration are intrinsic in the material itself, especially in relatively small, motile organisms like the ciliates. Some of the larger unicellular algae also have long been subjected to regeneration experiments. These provide more favorable material for various

reasons; they are large, can be dissected readily, and even enucleate, chlorophyll-bearing fragments are viable for long periods. Recent work on *Acetabularia*, a complex uninucleate form related to *Valonia*, has led Hämmerling (1934a and b) to some important discoveries of pertinence to the present discussion. This alga is highly polarized, consisting of a basal rhizoid with the single nucleus, an erect stalk, and a reproductive umbrella. By testing the regenerative potencies of fragments of individuals at different ages, Hämmerling discovered a remarkable nuclear control of morphogenesis. He was able to make quantitative biological assays of the formative influence, which seemed to be of a substantive nature. His conclusion was that formative substances originate in the nucleus and act along concentration-gradients which have their high points at sites of morphogenesis. If corroborated (and the data seem to be exceptionally clear-cut), this will prove to be the most direct evidence yet discovered of a causal mechanism in regeneration. A direct link can thereby be established between the production, distribution and action of morphogenetic substances, although they have not yet been identified chemically. It has been suggested that their migration in definite directions is probably due to the existence of physiological gradients similar to those identified in other plants and in animals.

The applicability of this mechanism to protozoan regeneration must be left to future investigations. It provides suggestive data which are in agreement with all of the known facts in Protozoa. It has been seen that Calkins' investigation of *Uronychia* (1911a) indicated that some kind of formative stimulus probably was transmitted from nucleus to cytoplasm (see *Ciliata*, above). His conclusion contained a supposition (adapted from specu-

lations by deVries and R. Hertwig) that is especially interesting in the light of the recent work on *Acetabularia*. It may well serve as the working-hypothesis for investigating the next important phase of the problem of regeneration in Protozoa: "... substances are formed in the nucleus and transferred to the cytoplasm, where they or the products of their activity accumulate until a condition analogous to saturation is reached. Cutting the cell at this period results in the exhaustion, through regeneration, of these substances..." (p. 115).

V. SUMMARY

1. An attempt has been made to treat comprehensively some of the major problems associated with regeneration in Protozoa.

2. The capacity for regeneration has been demonstrated in all principal groups of free-living Protozoa. The data involving parasitic forms (Sporozoa, etc.) are still too incomplete to permit of any definite conclusions.

3. From the available facts, it seems clear that the course of regeneration in each group is restricted by the developmental possibilities common to that group. In other words, regeneration involves the experimental counterpart of the normal limits of reorganization that occur at various phases of the life-history. This becomes explicable when we consider that one basic mechanism probably acts both during normal and experimental reorganization.

4. Few experiments have been performed on flagellates (Mastigophora), and these have involved complex forms of the Dinoflagellida and Volvocidae.

5. The pseudopodia-bearing Sarcodina have yielded some valuable results. In all instances the restoration of extirpated structures is dependent on the presence of

nuclear substance; even the more highly evolved groups have retained a high regenerative capacity.

6. The ciliates have yielded the most extensive data on regeneration. Their complex organization permits a great variety of experimental procedures.

(a) Of the dual nuclear apparatus, only the macronucleus can be shown to function in the actual regenerative process. The rôle of the micronucleus in this connection is as yet unclear; apparently it is more important in the viability of some forms than in others.

(b) The series of advancing structural complexity in the ciliates involves primarily a specialization of the oral region and of locomotor organelles. Correlated with this, the regenerative response tends to become restricted to the activity of *anlagen* of the organelles involved. This has been illustrated in the review by the comparative responses of the holotrichous *Paramecium*, the heterotrichous *Stentor* and the hypotrichous *Stylonychia*. In the Hypotrichina the regenerative response has become so highly integrated that removal of one motile organelle causes the complete reorganization of all locomotor and oral structures. These invariably develop in the same manner: primary differentiation within a reorganization field, and subsequent migration to their definitive positions. Evidence is given of physiological differences in the cytoplasm of young and adult individuals (Bauer and Granowskaja), which may throw some light on the data of Calkins (1911a), etc.

(c) Ciliates retain a marked regenerative capacity during the processes of fission, encystation and conjugation. Cutting experiments during fission often produce truncate offspring, attesting the presence of an irreversible division zone. The regenerative capacity during conjugation apparently is dependent on development of the new macronuclear anlage following meiosis.

7. Physiological regeneration has been reported in many Protozoa, and involves spontaneous replacement of structures. Evidence is available that at least some of these reports probably have mistaken restorative regeneration (induced by environmental stimuli) for a "normal growth process." Further investigations are highly desirable.

8. The nature of the mechanism underlying regeneration is still unsolved. There are many data, indirect and direct alike, which suggest an active, guiding rôle by the nuclear apparatus (macronucleus in ciliates). The nucleo-plasmic ratio may play an important part, but probably it comprises at best only one of a complex set of factors.

9. Recent work on *Acetabularia* may offer a promising working-hypothesis of a regenerative mechanism in Protozoa. In this unicellular alga formative stuffs are produced by the nucleus and are distributed along concentration-gradients to sites of morphogenesis. The activity of physiological gradients, such as have been demonstrated for Protozoa and other organisms, might explain the directional movements involved.

LIST OF LITERATURE

(1). General References

- (1) AWERINZEW, S. (1936). Zur Biologie des Infusors *Lagenophrys*. *Arch. Protistenk.*, 87, 131-41.
- (2) BALBIANI, E.-G. (1861). Recherches sur les phénomènes sexuels des Infusoires. *J.*

- Physiol.* (Brown-Sequard), 4, 102-30; 194-220; 431-448; 465-520.
- (3) BRADY, H. B. (1884). Report on the Foraminifera dredged by H. M. S. Challenger, during the years 1873-1876. *Rep. sci. results voyage H. M. S. Challenger, Zool.*, 9, xxi + 814 pp.

- (4) BÜTCHLI, O. (1876). Studien über die ersten Entwicklungsvorgänge der Eizelle, die Zelltheilung und die Conjugation der Infusorien. *Abb. senckenb. naturf. Ges.*, 10, 213-464.
- (5) —. (1886). Kleine Beiträge zur Kenntnis einiger mariner Rhizopoden. *Morph. Jahrb.*, 11, 78-101.
- (6) —. (1887-89). Protozoa. Infusoria und System der Radiolaria. *Bromm, Klass. Ordn. Thier-Reichs*, 1 (Abt. 3), 1098-1035.
- (7) CALKINS, G. N. (1912). The paedogamous conjugation of *Blepharisma undulans* St. J. *Morph.*, 23, 667-91.
- (8) — (1930). *Uroleptus balseyi* Calkins. 2. The origin and fate of the macronuclear chromatin. *Arch. Protistenk.*, 69, 151-74.
- (9) CARPENTER, W. B. (1883). Report on the specimens of the genus *Orbitolites*, collected by H. M. S. Challenger during the years 1873-1876. *Rep. sci. results voyage H. M. S. Challenger, Zool.*, 7 (4), 1-47.
- (10) —, PARKER, W., AND JONES, T. (1862). Introduction to the Study of the Foraminifera. xiv + 319 pp. London (Hardwicke).
- (11) CHATTON, É. AND VILLENBUEVE, S. (1937). La division de la bouche et la formation du péristome chez les Péritriches (*Cyclochaeta astropsectinis* n. sp.). Leur continuité génétique immédiate. *C. R. Acad. Sci. Paris*, 204, 538-41.
- (12) CHILD, C. M. (1914). The axial gradient in ciliate Infusoria. *Biol. Bull.*, 26, 36-54.
- (13) CLAPARÈDE, E. AND LACHMANN, J. (1858-61). Études sur les Infusoires et les Rhizopodes. I. Anatomie et classification des Infusoires. II. Anatomie et classification des Rhizopodes. III. De la reproduction des Infusoires. *Mém. Inst. nat. génév.*, 5-6, 482 pp.; 7, 291 pp.
- (14) DOBELL, C. C. (1911). The principles of protistology. *Arch. Protistenk.*, 23, 269-310.
- (15) DUJARDIN, F. (1838). Mémoire sur l'organisation des Infusoires. *Ann. Sci. nat. (Ser. 2), Zool.*, 10, 230-315.
- (16) — (1841). Histoire naturelle des Zoophytes. Infusoires, etc. xii + 684 pp. Paris (Fain and Thunot).
- (17) EHRENBERG, C. G. (1838). Die Infusions-thierchen als vollkommene Organismen. xviii + 547 pp. Leipzig (Voss).
- (18) EICHORN, J. C. (1783). Zugabe zu meinen Beyträgen zur Natur-Geschichte der kleinsten Wasser-Thiere—etc. 24 pp. Darmzig (Müller).
- (19) ELLIS, J. (1769). Observations on a particular manner of increase in the animalcula of vegetable infusions, etc. *Philos. Trans.*, 59, 138-52.
- (20) GUANZATI, L. (1796). Osservazione e sperienze intorno ad un prodigioso animaluccio delle infusioni. *Opusc. scelti scienze arti*, 19, 3-21. (Reported in excerpt by von Siebold, C. (1855)). *Z. wiss. Zool.*, 6, 432-42.
- (21) HAECKEL, E. (1870). Biologische Studien. I. Heft. Studien über Moneren und andere Protisten, nebst einer Rede über Entwicklungsgang und Aufgabe der Zoologie. xx + 184 pp. Leipzig (Engelmann).
- (22) HAMMERLING, J. (1934a). 1. Über formbildende Substanzen bei *Acetabularia mediterranea*, ihre räumliche und zeitliche Verteilung und ihre Herkunft. *Arch. Entomoch. Org.*, 131, 1-81.
- (23) — (1934b). Über Genomwirkungen und Formbildungsfähigkeit bei *Acetabularia*. *Arch. Entomoch. Org.*, 132, 424-62.
- (24) HAMMOND, D. (1937). The neuromotor system of *Euplotes patella* during binary fission and conjugation. *Quart. J. Micr. Sci.*, 79, 507-57.
- (25) HEILBRUNN, L. V. (1934). The action of anaesthetics on living protoplasm. *Proc. Amer. Philos. Soc.*, 74, 159-65.
- (26) KLEIN, B. (1929). Weitere Beiträge zur Kenntnis des Silberliniensystems der Ciliaten. *Arch. Protistenk.*, 65, 183-257.
- (27) KORSCHULT, E. (1927). Regeneration und Transplantation. I. Bd.: Regeneration. 818 pp. Berlin (Bornträger).
- (28) LOEB, J. (1899). Warum ist die Regeneration kernloser Protoplaststücke unmöglich oder erschwert? *Arch. Entomoch. Org.*, 8, 689-93.
- (29) LYNCH, V. (1919). The function of the nucleus of the living cell. *Amer. J. Physiol.*, 48, 258-83.
- (30) MAUPAS, E. (1889). La rejeunissement karyogamique chez les ciliés. *Arch. Zool. exp. gén.* (2), 7, 149-517.
- (31) MORGAN, T. H. (1901a). Regeneration. xii + 316 pp. New York (Macmillan).
- (32) PARKER, A. (1883). Reproduction in *Ampipleps fasciola*. *Proc. Acad. Nat. Sci. Phila.*, 35, 313-14.
- (33) PENARD, E. (1902). Faune rhizopodique du bassin du Léman. 714 pp. Genève (Kündig).
- (34) PERTT, M. (1852). Zur Kenntniss kleinster Lebensformen nach Bau, Funktionen, Systematik, mit Specialverzeichniss der in der Schweiz beobachteten. viii + 228 pp. Bern. (Jent. and Reinert).

- (35) PRZIBRAM, H. (1909). Experimental-Zoologie. 2. Regeneration. viii + 338 pp. *Leipzig and Wien* (Deuticke).
- (36) — (1929). *Ibid.* 6. Zoonomie. viii + 431 pp. *Ibid.*
- (37) SCHMITZ, F. (1879). Beobachtungen über die vielkernigen Zellen der Siphonocladaceen. Festschr. naturf. Ges. *Halle*, 273-320.
- (38) SCHULTZE, M. (1863). Das Protoplasma der Rhizopoden und der Pflanzenzellen. iv + 68 pp. *Leipzig* (Engelmann).
- (39) STEIN, F. (1859). Der Organismus der Infusionsthier nach eigenen Forschungen in systematischer Reihenfolge bearbeitet. I. Abt. Allgemeiner Theil und Naturgeschichte der hypotrichen Infusionsthier. xii + 206 pp. *Leipzig* (Engelmann).
- (40) SUMMERS, F. (1935). The division and reorganization of the macronuclei of *Aspidisca lynceus* Müller, *Diophrys appendiculata* Stein, *Stylonychia pustulata* Ehrbg. *Arch. Protistenk.*, 85, 173-208.
- (41) VERWORN, M. (1889). Die polare Erregung der Protisten durch den galvanischen Strom. *Pflüg. Arch. ges. Physiol.*, 45, 1-36.
- (42) WORCESTER, G. (1884). The life history of *Stentor coeruleus*, or blue Stentor. *Proc. Cent. Ohio Sci. Ass.*, 1 (part 1), 97-106.
- (43) WRĘŚNIEWSKI, A. (1870). Beobachtungen über Infusorien aus der Umgebung von Warschau. *Z. wiss. Zool.*, 20, 467-511.
- (44) YOUNG, D. (1939). Macronuclear reorganization in *Blepharisma undulans*. *J. Morph.*, 64, 297-353.
- (2). *Experimental studies of regeneration.*
Physiological regeneration
- (45) BALAMUTH, W. (1939). Microscopic anatomy and regenerative behavior of a complex heterotrichous ciliate, *Licnophora macfarlandi*. *Anat. Rec.*, 75 (Supp.), 86.
- (46) BALBIANI, E.-G. (1888). Recherches expérimentales sur la mérotomie chez les Infusoires ciliés. Contribution à l'étude du rôle physiologique du noyau cellulaire. *Rec. zool. suisse*, 5, 1-72.
- (47) — (1891a). Sur les régénérations successives du péristome comme caractère d'âge chez les Stentors et sur le rôle du noyau dans ce phénomène. *Zool. Anz.*, 14, 312-16.
- (48) — (1891b). Sur la formation des monstres doubles chez les Infusoires. *J. Anat. Physiol.*, 27, 169-96.
- (49) — (1892). Nouvelles recherches expérimentales sur la mérotomie des Infusoires ciliés. I. *Ann. Micrograph.*, 4, 369-407; 449-489.
- (50) BALBIANI, E.-G. (1893). *Ibid.* II. *Ann. Micrograph.*, 5, 1-25; 49-84; 113-37.
- (51) — (1899). Études sur l'action des sels sur les Infusoires. *Arch. Anat. micr.*, 2, 518-600.
- (52) BAUER, E., AND GRANOWSKAJA, A. (1934a). Die Rekonstruktion des Kerns und die Atmungsprozesse bei Hypotricha im Ergebnisse operativer Einwirkungen auf das Protoplasma und ihre Abhängigkeit vom Alter. (Russian with German summary.) *Biol. Zb. (Mosk.)*, 3, 457-64.
- (53) — (1934b). Abhängigkeit der experimentellen "individuellen Unsterblichkeit" vom Alter. (Russian with German summary.) *Biol. Zb. (Mosk.)*, 3, 609-18.
- (54) BLOCHMANN, F. (1887-89). Reported in: Bütschli, O. (1887-89). Protozoa. Infusoria und System der Radiolaria. *Bronn, Klass. Ordn. Thier-Reichs*, 1 (Abt. 3), 1098-2035.
- (55) BOCK, F. (1926). Experimentelle Untersuchungen an koloniebildenden Volvocaceen. *Arch. Protistenk.*, 56, 321-56.
- (56) BRANDT, K. (1877). Über Actinosphaerium Eichhornii. Dissertation. *Halle*. 54 pp.
- (57) BURNSIDE, L. (1929). Relation of body size to nuclear size in *Stentor coeruleus*. *J. Exp. Zool.*, 54, 473-83.
- (58) BUSCH, W. (1851). Beobachtungen über Anatomie und Entwicklung einiger wirbellosen Seethiere. viii + 143 pp. *Berlin* (Hirschwald).
- (59) CALKINS, G. N. (1911a). Regeneration and cell division in *Uronychia*. *J. Exp. Zool.*, 10, 95-116.
- (60) — (1911b). Effects produced by cutting *Paramecium* cells. *Biol. Bull.*, 21, 36-72.
- (61) — (1921). *Uroleptus mobilis* Engelm. 4. Effect of cutting during conjugation. *J. Exp. Zool.* 34, 449-470.
- (62) CAUBIN, M. (1931). La régénération du *Stentor coeruleus*. *Arch. Anat. micr.*, 27, 107-25.
- (63) CHATTON, É., AND LWOFF, A. (1936). Les remaniements et la continuité du cinétome au cours de la scission chez les Thigmotriches Ancistrumidés. *Arch. Zool. exp. gén.*, 78, 84-91.
- (64) —, —, LWOFF, M., AND MONOD, J.-L. (1931). La formation de l'ébauche buccale postérieure chez les Ciliés en division et ses relations de continuité topographique et génétique avec la bouche antérieure. *C. R. Soc. Biol. Paris*, 108, 540-44.

- (65) ČERNÝEC, M. (1932). Regulation und Regeneration von *Paramecium caudatum*. (Polish with German summary.) *Acta Biol. gen.*, 7, 115-34.
- (66) CIENKOWSKI, L. (1871). Über Schwärmerbildung bei Radiolarien. *Arch. mikr. Anat.*, 7, 372-81.
- (67) — (1873). Über *Noctiluca miliaris* Sur. *Arch. mikr. Anat.*, 9, 47-61.
- (68) DELLINGER, O. (1906). Locomotion of amoebae and allied forms. *J. Exp. Zool.*, 3, 337-58.
- (69) DEMBOWSKA, W. (1925). Studien über die Regeneration von *Stylonychia mytilus*. *Arch. Entwuch. Org.*, 104, 185-209.
- (70) — (1926). Studies on the regeneration of protozoa. 2. Regeneration of the ciliary apparatus in some marine Hypotricha. *J. Exp. Zool.*, 43, 485-504.
- (71) — (1938). Körperreorganisation von *Stylonychia mytilus* beim Hungern. *Arch. Protistenk.*, 91, 89-105.
- (72) DEMBOWSKI, J. (1913). Versuche über die Merotomie der Gregarinen. *Arch. Protistenk.*, 29, 1-21.
- (73) DÖNITZ, W. (1868). Über *Noctiluca miliaris* Sur. *Arch. Anat., Physiol., wiss. Med.*, 137-49; 750.
- (74) DUJARDIN, F. (1835). Recherches sur les organismes inférieurs. *Ann. Sci. nat.* (2), 4, 343-77.
- (75) ENRIQUEZ, P. (1912). Il dualismo nucleare negli Infusori e il suo significato morfologico e funzionale. 2. Die Nahrung und die Struktur des Macronucleus. *Arch. Protistenk.*, 26, 420-34.
- (76) FAURÉ-FREMIET, E. (1906). Sur un cas de monstruosité chez *Stentor coerulesus*. *Arch. Anat. micr.*, 8, 660-66.
- (77) — (1910). La division de l'*Urostyla grandis*. Expériences de mérotomie. *Bull. sci. Fr. Belg.*, 44, 215-19.
- (78) GARNJOBST, L. (1937). A comparative study of protoplasmic reorganization in two hypotrichous ciliates, *Stylonychia mytilus* and *Euplotes taylori*, with special reference to cymest. *Arch. Protistenk.*, 89, 317-81.
- (79) GELI, J. VON (1935). Der Richtungsmeridian und die Neubildung des Mundes während ausserhalb der Teilung bei den Ziliaten. *Biol. Zbl.*, 55, 436-45.
- (80) GREIFF, R. (1867). Über *Actinophrys Eichenii* und einen neuen Süßwasserhizopoden, besonders in Rücksicht auf Theilbarkeit derselben resp. Vermehrung durch künstliche Theilung. *Arch. mikr. Anat.*, 3, 396-403.
- (81) GREGORY, L. (1909). Observations on the life history of *Tillina magna*. *J. Exp. Zool.*, 6, 383-431.
- (82) GROSSE-ALLERMANN, W. (1909). Studien über *Amoeba terricola* Greeff. *Arch. Protistenk.*, 17, 203-57.
- (83) GRUBER, A. (1883a). Über die Einflusslosigkeit des Kerns auf die Bewegung, die Ernährung und das Wachstum einzelliger Tiere. *Biol. Zbl.*, 3, 580-82.
- (84) — (1883b). Untersuchungen über einige Protozoen. *Z. wiss. Zool.*, 38, 45-70.
- (85) — (1885a). Über künstliche Teilung bei Infusorien. *Biol. Zbl.*, 4, 717-22.
- (86) — (1885b). *Ibid.* II. *Biol. Zbl.*, 5, 137-41.
- (87) — (1886). Beiträge zur Kenntniss der Physiologie und Biologie der Protozoen. *Ber. naturf. Ges. Freiburg, i. B.*, 1, 33-56.
- (88) GRUBER, K. (1912). Biologische und experimentelle Untersuchungen an *Amoeba proteus*. *Arch. Protistenk.*, 25, 316-76.
- (89) HAMBURGER, C. (1903). Beiträge zur Kenntnis von *Trachelius ovum*. *Arch. Protistenk.*, 2, 445-74.
- (90) HARTMANN, M. (1922). Über den dauernden Ersatz der ungeschlechtlichen Fortpflanzung durch fortgesetzte Regenerationen. *Biol. Zbl.*, 42, 364-81.
- (91) HARTMANN, M. (1924). Der Ersatz der Fortpflanzung von Amöben durch fortgesetzte Regenerationen. *Arch. Protistenk.*, 49, 447-64.
- (92) — (1928). Über experimentelle Unsterblichkeit von Protozoen-Individuen. Ersatz der Fortpflanzung von *Amoeba proteus* durch fortgesetzte Regenerationen. *Zool. Jahrb., Abt. Physiol.*, 45, 973-87.
- (93) HEONER, R. W. (1920). The relations between nuclear number, chromatin mass, cytoplasmic mass, and shell characteristics in four species of the genus *Arcella*. *J. Exp. Zool.*, 30, 1-95.
- (94) HERTWIG, R. (1876). Zur Histologie der Radiolarien. Untersuchungen über den Bau und die Entwicklung der Sphaerozoiden und Thalassicolleiden. 91 pp. Leipzig (Engelmann).
- (95) HETHERINGTON, A. (1932). On the absence of physiological regeneration in *Stentor coerulesus*. *Arch. Protistenk.*, 77, 58-63.
- (96) HEWITT, J. (1914). Regeneration of *Pleurotricha* after merotomy with reference especially to the number of micronuclei and the

- occurrence of uninucleate cells. *Biol. Bull.*, 27, 169-76.
- (97) HOFER, B. (1890). Experimentelle Untersuchungen über den Einfluss des Kerns auf das Protoplasma. *Jena. Z. Naturw.*, 24, 105-76.
- (98) HOLMES, S. (1907). The behavior of *Loxophyllum* and its relation to regeneration. *J. Exp. Zool.*, 4, 399-418.
- (99) HOSOI, T. (1937). Protoplasmic streaming in isolated pieces of *Paramecium*. *J. Fac. Sci. Imp. Univ. Tokyo (IV-Zool.)*, 4, 299-305.
- (100) HUBER-PESTALOZZI, G. (1922). Über Bruchdreifachbildung bei einem einzelligen Organismus. (*Ceratium hirundinella* O.F.M.). *Arch. Entwemch. Org.*, 52, 276-80.
- (101) HÜBNER, O. (1902). Neue Versuche aus dem Gebiet der Regeneration und ihre Beziehungen zu Anpassungserscheinungen. *Zool. Jahrb., Abt. Syst.*, 15, 461-98.
- (102) ISHIKAWA, H. (1912). Wundheilungs- und Regenerationsvorgänge bei Infusorien. *Arch. Entwemch. Org.*, 35, 1-29.
- (103) JENNINGS, H. S. (1908). Heredity, variation and evolution in Protozoa. 1. The fate of new structural characters in *Paramecium*, in connection with the problem of the inheritance of acquired characters in unicellular organisms. *J. Exp. Zool.*, 5, 577-632.
- (104) JOFF, N. A. (1923). Über Regeneration bei Infusorien. (Russian with German summary). *Russk. Arkh. Protist.*, 2, 220-29.
- (105) JOHNSON, H. P. (1893). A contribution to the morphology and biology of the Stentors. *J. Morph.*, 8, 467-562.
- (106) KLEIN, B. (1928). Die Silberliniensysteme der Ciliaten. Weitere Resultate. *Arch. Protistenk.*, 62, 177-260.
- (107) KOFOID, C. (1908). Exuviation, autotomy and regeneration in *Ceratium*. *Univ. Calif. Pub. Zool.*, 4, 345-86.
- (108) LEDANTEC, F. (1894). Études biologiques comparatives sur les Rhizopodes lobés et réticulés d'eau douce. *Bull. sci. Fr. Belg.*, (IV) 5, 56-99.
- (109) — (1897). La régénération du micronucléus chez quelques Infusoires ciliés. *C. R. Acad. Sci. Paris*, 125, 51-2.
- (110) LÉGER, L. AND DUBOUCQ, O. (1904). Nouvelles recherches sur les Grégarines et l'épithélium intestinal des Trachéates. *Arch. Protistenk.*, 4, 335-83.
- (111) LEGER, J. (1926). Zellphysiologische Experimente mit Ciliaten. *Mikrokosmos*, 20, 54-6.
- (112) LEWIN, K. (1910). Nuclear relations of *Paramecium caudatum* during the asexual period. *Proc. Camb. Philos. Soc.*, 16, 39-41.
- (113) — (1911). The behaviour of the infusorian micronucleus in regeneration. *Proc. Roy. Soc.*, B 84, 332-44.
- (114) LILLIE, F. (1896). On the smallest parts of *Stentor* capable of regeneration; a contribution on the limits of divisibility of living matter. *J. Morph.*, 12, 239-49.
- (115) LUCAS, M. (1932). The cytoplasmic phases of rejuvenescence and fission in *Cyatodinium piriforme*. II. A type of fission heretofore undescribed for ciliates. *Arch. Protistenk.*, 77, 407-23.
- (116) LUND, E. J. (1917). Reversibility of morphogenetic processes in *Bursaria*. *J. Exp. Zool.*, 24, 1-34.
- (117) MACDOUGALL, M. (1925). Cytological observations on gymnostomatous ciliates, with a description of the maturation phenomena in diploid and tetraploid forms of *Chilodon uncinatus*. *Quart. J. Micr. Sci.*, 69, 361-84.
- (118) MARTINI, E. (1905). Beobachtungen an *Arcella vulgaris*. *Z. wiss. Zool.*, 79, 574-619.
- (119) MOODY, J. (1912). Observations on the life-history of two rare ciliates, *Spathidium spathula* and *Actinobolus radians*. *J. Morph.*, 23, 349-407.
- (120) MOORE, E. L. (1924). Regeneration at various phases in the life-history of *Spathidium spathula* and *Blepharisma undulans*. *J. Exp. Zool.*, 39, 249-316.
- (121) MORGAN, T. H. (1901b). Regeneration of proportionate structures in *Stentor*. *Biol. Bull.*, 2, 311-28.
- (122) NADLER, J. (1929). Notes on the loss and regeneration of the pellicle in *Blepharisma undulans*. *Biol. Bull.*, 56, 327-30.
- (123) NUSSBAUM, M. (1884). Über spontane und künstliche Zelltheilung. *Sitzber. niederrhein. Ges. Nat.-u. Heilk., Bonn* 41, 259-63.
- (124) — (1886). Über die Theilbarkeit der lebendigen Materie. 1. Die spontane und künstliche Theilung der Infusorien. *Arch. mikr. Anat.*, 26, 485-538.
- (125) OKADA, Y. (1930). Transplantationsversuche an Protozoen. *Arch. Protistenk.*, 69, 39-94.
- (126) PERBLES, F. (1912). Regeneration and regulation in *Paramecium caudatum*. *Biol. Bull.*, 23, 154-70.
- (127) PENARD, E. (1900). Essais de mérotomie sur quelques Diffugiés. *Rev. suisse Zool.*, 8, 477-90.

- (128) PENARD, E. (1905). Observations sur les Amibes à pellicule. *Arch. Protistenk.*, 6, 175-206.
- (129) PHELPS, L. A. (1926). Experimental analysis of factors concerned in division in *Amoeba*. *Trans. Amer. Micr. Soc.*, 45, 133-45.
- (130) PIETSCHMANN, —. (1909). Reported in: PRZIBRAM, H. (1909). Experimental-Zoologie. 2. Regeneration. viii + 338 pp. *Leipzig and Wien* (Deuticke).
- (131) POPOFF, M. (1908). Experimentelle Zellstudien. *Arch. Zellforsch.*, 1, 245-379.
- (132) — (1909). Experimentelle Zellstudien. 2. Über die Zellgrösse, ihre Fixierung und Vererbung. *Arch. Zellforsch.*, 3, 124-80.
- (133) POUCHET, G. (1885). Nouvelle contribution à l'histoire des Péridiniens marins. *J. Anat. Physiol.*, 21, 28-88.
- (134) PRATJE, A. (1921). *Noctiluca miliaris* Suriray. Beiträge zur Morphologie, Physiologie und Cytologie. 1. Morphologie und Physiologie. *Arch. Protistenk.*, 42, 1-98.
- (135) PROWAZEK, S. VON (1898). Protozoenstudien. *Arch. zool. Inst. Univ. Wien*, 11, 195-268.
- (136) — (1901). Beiträge zur Protoplasmaphysiologie. *Biol. Zbl.*, 21, 87-95; 144-55.
- (137) — (1903a). Beitrag zur Kenntnis der Regeneration und Biologie der Protozoen. *Arch. Protistenk.*, 3, 44-59.
- (138) — (1903b). Degenerative Hyperregeneration bei den Protozoen. *Arch. Protistenk.*, 3, 60-3.
- (139) — (1913). Studien zur Biologie der Protozoen. VI. *Arch. Protistenk.*, 31, 47-71.
- (140) REYNOLDS, M. E. C. (1932). Regeneration in an amiconucleate infusorian. *J. Exp. Zool.*, 62, 327-61.
- (141) RUMBELER, L. (1902). Die Doppelschalen von *Orbitolites* und anderer Foraminiferen, vom entwicklungsmechanischen Standpunkt aus betrachtet. *Arch. Protistenk.*, 1, 193-296.
- (142) RUNYAN, E. AND TORREY, H. (1914). Regulation in *Vorticella*. *Biol. Bull.*, 27, 343-45.
- (143) SCHMÄHL, O. (1926). Die Neubildung des Peristoms bei der Teilung von *Bursaria truncatella*. *Arch. Protistenk.*, 54, 359-430.
- (144) SCHNEIDER, A. (1867). Zur Kenntnis des Baues der Radiolarien. *Arch. Anat., Physiol., wiss. Med.*, 509-11.
- (145) SCHUBERG, A. (1890). Zur Kenntniss der *Stentor coerules*. *Zool. Jahrb., Abt. Anat.*, 4, 197-238.
- (146) SCHULTZ, E. (1915). Die Hyle des Lebens. 1. Beobachtungen und Experimente an *Astrorhiza limicola*. *Arch. Entwemch. Org.*, 41, 215-36.
- (147) SCHWARTZ, V. (1934). Versuche über Regeneration und Kerndimorphismus der Cilienten. *Nachr. Ges. Wiss. Göttingen, Math.-Phys. Kl. Fachgr. VI, N. F.*, 1, 143-55.
- (148) — (1935). Versuche über Regeneration und Kerndimorphismus bei *Stentor coerules* Ehrbg. *Arch. Protistenk.*, 85, 100-39.
- (149) SKYD, E. (1936). Studies on the regulation of *Spirostomum ambiguum* Ehrbg. *Arch. Protistenk.*, 86, 454-70.
- (150) SOKOLOFF, B. (1924). Das Regenerationsproblem bei Protozoen. *Arch. Protistenk.*, 47, 143-252.
- Note: Several previous investigations of the author, some in Russian, are summarized adequately in his review. See that bibliography for further details.
- (151) STEVEN, N. M. (1903a). Notes on regeneration in *Stentor coerules*. *Arch. Entwemch. Org.*, 16, 461-75.
- (152) — (1903b). Further studies on the ciliate Infusoria, *Limnophora* and *Boveria*. *Arch. Protistenk.*, 3, 1-43.
- (153) ŠTOLC, A. (1910). Über kernlose Individuen und kernlose Teile von *Amoeba proteus*. *Arch. Entwemch. Org.*, 29, 152-68.
- (154) SUMMERS, F. (1938a). Some aspects of normal development in the colonial ciliate *Zoëthamnium alternans*. *Biol. Bull.*, 74, 117-29.
- (155) — (1938b). Form regulation in *Zoëthamnium alternans*. *Ibid.*, 74, 130-54.
- (156) TARTAR, V. (1938a). Regeneration in the Genus *Paramecium*. Dissertation (Yale University). 108 pp.
- (157) — (1938b). Regeneration in the starfish *Linckia* and in the protozoan *Condyllostoma*. *Ann. Rep. Tortugas Lab., Carneg. Instn. of Wash.*, 1937-38, 99-102.
- (158) — (1939). The so-called racial variation in the power of regeneration in *Paramecium*. *J. Exp. Zool.*, 81, 181-208.
- (159) TAYLOR, C. V. (1920). Demonstration of the function of the neuromotor apparatus in *Euplates* by the method of microdissection. *Univ. Calif. Pub. Zool.*, 19, 403-70.
- (160) — (1923). Removal of the micronucleus in *Euplates*. *Anat. Rec.*, 26, 376.
- (161) — (1928). Protoplasmic reorganization in *Uronychia uncinata*, n. sp., during binary fission and regeneration. *Physiol. Zool.*, 1, 1-25.
- (162) — AND FARRER, W. (1924). Fatal effects of the removal of the micronucleus in *Euplates*. *Univ. Calif. Pub. Zool.*, 26, 131-44.

- (163) TITTLER, I. (1938). Regeneration and reorganization in *Uroleptus mobilis* following injury by induced electric currents. *Biol. Bull.*, 75, 533-41.
- (164) VÁPENÍK, J. (1927). Beiträge zum Studium der Protoplasmahysteresis und der hystere-tischen Vorgänge. (Zur Kausalität des Alterns). 16. Über den Verlauf der wiederholten Regeneration bei Protisten. *Arch. Entwmech. Org.*, 112, 293-96.
- (165) VERWORN, M. (1888). Biologische Protis-ten-Studien. *Z. wiss. Zool.*, 46, 455-70.
- (166) — (1892). Die physiologische Bedeutung des Zellkerns. *Pflüg. Arch. ges. Physiol.*, 51, 1 118.
- (167) WALLENGREN, H. (1901). Zur Kenntniss des Neubildungs- und Resorptionsprocesses bei der Theilung der hypotrichen Infusorien. *Zool. Jahrb., Abt. Anat.*, 15, 1-58.
- (168) WALLENGREN, H. (1902). Inanitionserscheinungen der Zelle. Untersuchungen an Protozoen. *Z. allg. Physiol.*, 1, 67-128.
- (169) WEBB, W. (1855). On the *Noctiluca miliaris*. *Quart. J. Micr. Sci.*, 3, 102-6.
- (170) WILLIS, H. (1916). The influence of the nucleus on the behavior of *Amoeba*. *Biol. Bull.*, 30, 253-70.
- (171) YOUNG, D. B. (1922). A contribution to the morphology and physiology of the genus *Uronychia*. *J. Exp. Zool.*, 36, 353-95.
- (172) — (1926). Nuclear regeneration in *Stylonychia mytilus*. *Biol. Bull.*, 51, 163-5.
- (173) ZÜLZER, M. (1909). Bau und Entwicklung von *Wagnerella borealis* Mereschk. *Arch. Protistenk.*, 17, 135 202.





ACQUIRED IMMUNITY FROM PLANT VIRUS DISEASES

By W. C. PRICE

Department of Animal and Plant Pathology, The Rockefeller Institute for Medical Research, Princeton, New Jersey

ACQUIRED immunity from virus diseases has been studied by a number of phytopathologists in the decade since 1928. Much of the literature on the subject has not, however, come to the attention of biologists in general. Moreover, plant virus workers in many instances have apparently failed to recognize the significance and usefulness of the immune reaction for determining natural relationships of plant viruses. For these reasons, a general review paper may be of value to those who wish to acquaint themselves with progress in the field. In order to avoid lengthening the paper unnecessarily, discussion will be restricted entirely to virus diseases. The literature on the highly controversial subject of acquired immunity from bacterial and fungous diseases of plants was reviewed by Chester (19) in 1933.

THE MEANING OF ACQUIRED IMMUNITY

A clear understanding of what is meant by acquired immunity is necessary for proper evaluation of the data and conclusions which follow. While not all pathologists agree as to what constitutes acquired immunity, there seems to be general agreement in medicine that it is relative rather than absolute (55, 15, 25, 101, 106, 118). From this viewpoint, it may be defined as the resistance an individual organism acquires to a disease.

It is necessary to add further that this resistance is specific in order to exclude changes in susceptibility induced by nutrition or aging of the host and by such environmental factors as would be apt to alter resistance not only to the disease in question but also to various other unrelated diseases.

Acquired immunity may be either active or passive. It is active if induced by infection with a parasitic agent, passive if induced by injection with immune serum or antibodies obtained from other individuals. Active immunity is well known in virus diseases of both animals and plants. On the other hand, passive immunity, well known in virus diseases of animals, has not been demonstrated in plants and need not be further considered here. (Since this paper was prepared for publication certain experiments reported by Wallace (*Phytopathology* 30: 673-679, 1940) were interpreted as giving evidence of the presence of antibody-like substances in tobacco plants recovered from the curly top disease.)

Active immunity may be classified into three types, the chronic-disease type, the carrier type, and the sterile type. The chronic-disease type involves neither disappearance of the immunizing disease nor disappearance of the causal agent. The individual becomes solidly immune from a severe type of disease but suffers from a chronic mild disease. The carrier type

of acquired immunity involves persistence of the disease agent but disappearance of obvious manifestations of disease. In some diseases inducing this type of immunity, the individual is permanently protected from a second attack even when subjected to massive reinoculations with the infective agent. The sterile type of acquired immunity has not yet been demonstrated for plant virus diseases. In this type, not only do obvious signs of disease disappear, but the inciting agent disappears also, or at least cannot be detected by ordinary methods. The sterile type may be transitory or permanent and readily or with difficulty broken down by massive inoculation. Finally, it must be recognized that there is no sharp line of division between the three types of acquired immunity. The extent to which the concentration of the pathogenic agent is reduced determines whether the immunity is of the sterile or carrier type. The extent to which signs of disease disappear determines whether it is of the carrier or chronic-disease type.

In the discussion which follows, acquired immunity from plant virus diseases will be considered under two main headings, immunity following recovery from disease and, second, cross immunity in which infection with one strain of a virus protects from infection by closely related strains of the same virus. The immunity following recovery from disease is of the carrier type. Cross immunity may be either of the carrier or of the chronic-disease type.

IMMUNITY FOLLOWING RECOVERY FROM DISEASE

Tobacco ring spot. Tobacco ring spot was the first virus disease of higher plants in which acquired immunity was demonstrated. The disease was first described by Fromme and Wingard (34) in 1922

but is known to have existed as early as 1917 in tobacco fields of Virginia. Its infectious nature was determined by Fromme, Wingard, and Priode (35). The causal virus is readily transmitted to susceptible plants by rubbing their leaves with a gauze pad saturated with juice from infected plants. Tobacco (*Nicotiana tabacum* L.) plants inoculated in this manner develop a characteristic type of lesion on inoculated leaves in about 3 days. The primary lesion consists of concentric necrotic rings alternating with normal green tissue, hence the name, ring spot. In 3 or 4 more days, the virus spreads systemically and produces secondary lesions similar to the primary ones but generally larger and more irregular. In from 12 to 35 days after inoculation, depending on the growth rates of infected plants and their age when inoculated, diseased tobacco plants begin to recover. Recovery is initiated by the development of leaves in which lesions are confined to apical portions, leaving the basal portions healthy in appearance. The healthy-appearing basal portion and the diseased apical portion are usually demarcated by irregular necrotic lines which tend to follow along veins and form an outline similar to that of an oak leaf. In subsequently produced leaves, the lesions and oak-leaf patterns are restricted to progressively smaller areas at the leaf tips until, finally, such symptoms completely fail to appear (Fig. 1). Leaves produced after this stage has been reached closely resemble those of healthy plants but are slightly darker in color, somewhat thicker, and of a more leathery texture. Recovered plants appear to grow somewhat less rapidly than healthy plants.

Wingard (115) was the first to report recovery from tobacco ring spot and to suggest that certain plants might acquire immunity from this disease. He failed

to produce ring-spot symptoms⁷ on recovered leaves by inoculating them heavily with ring-spot virus. The recovered plants were not, however, free of virus, and juice from recovered portions readily

or development of immunity, or whatever it is, seems to hold under greenhouse conditions for practically all the plants tested." Henderson and Wingard (38) confirmed Wingard's original observation

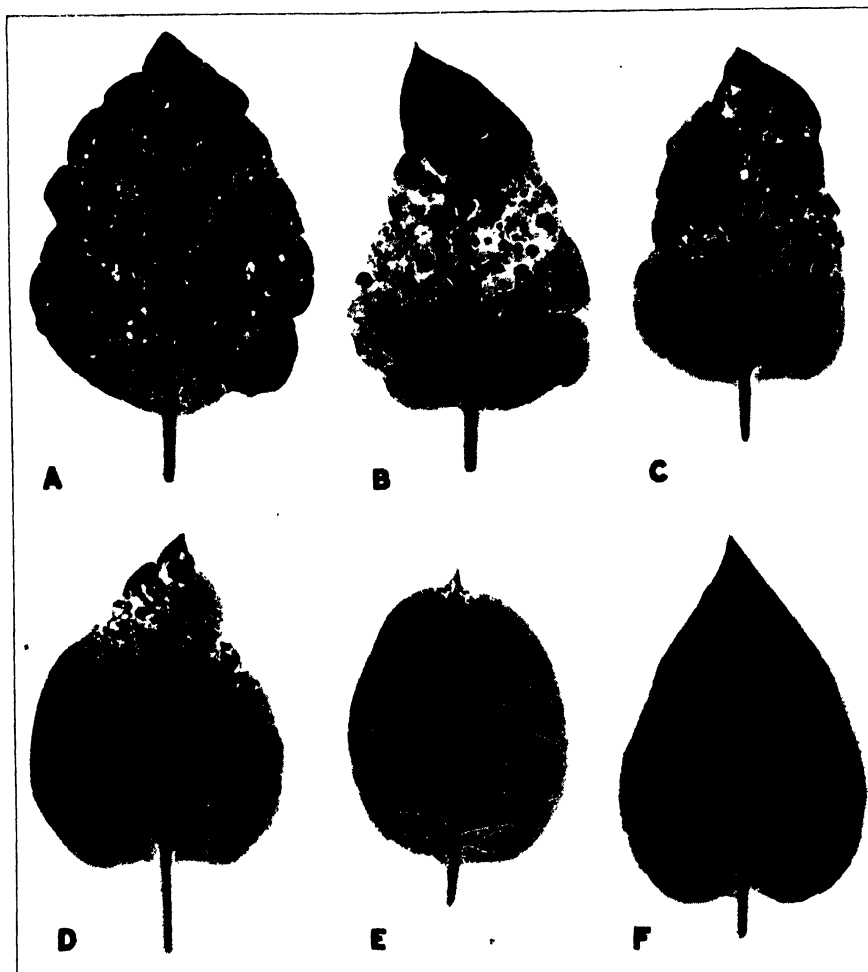


FIG. 1. LEAVES OF TURKISH TOBACCO ILLUSTRATING SUCCESSIVE STAGES IN RECOVERY FROM RING SPOT

A, leaf produced early in the course of the disease, showing acute symptoms; B, to E, leaves produced later, showing progressively fewer symptoms; F, healthy-appearing leaf produced still later after the plant had recovered. (After Price, 76.) (Photograph by L. P. Flory.)

produced typical ring-spot symptoms when used to inoculate healthy plants. Wingard transmitted the disease to plants of 38 genera in 17 different families and reported that "this masking of symptoms,

and reported further that the symptoms remained "masked" for a period of a year in tobacco plants grown through several generations by cuttings from recovered plants.

The observation of Wingard was of considerable importance to plant pathology since here, for the first time, was definite evidence that plants might acquire immunity from disease—something hitherto regarded as unlikely by most plant pathologists. On the other hand, it was possible to explain his observation on the basis of masking of symptoms. Masking occurs when plants are grown under conditions unfavorable for symptom expression, the symptoms reappearing when the conditions become favorable. It had previously been observed for other virus diseases (36, 50, 10).

Price (76) therefore made a special study of tobacco ring spot in order to determine whether the condition reported by Wingard really was acquired immunity or whether it was merely masking of symptoms. He was able to confirm the observations previously reported that tobacco and certain other species of plants invariably recover from tobacco ring spot, that the healthy-appearing leaves of recovered plants carry the virus, and that they cannot be induced to produce symptoms by reinoculation. He showed further that this recovery and immunity to reinfection takes place under a wide range of environmental conditions and that it is entirely distinct from the masking of symptoms that occurs in the case of a few other virus diseases under certain environmental conditions. Plants grown under favorable environmental conditions from cuttings of recovered plants were repeatedly inoculated with ring-spot virus, but in no case did symptoms develop, whereas plants grown from cuttings of healthy plants and treated in exactly the same manner invariably came down with the disease (Fig. 2). Acquired immunity was thus demonstrated for 4 species of *Nicotiana* and for 10 varieties of *N.*

tabacum. It was concluded that the phenomenon observed constituted an acquired immunity similar to that which obtains in the case of many virus diseases of animals.

Valleau (110, 111) concluded that tobacco plants do not recover and do not acquire immunity from tobacco ring-spot disease. He maintained that symptoms are produced only when the growing point of the plant has not been completely invaded by virus, that leaves developed subsequent to invasion are parasitized although patternless, and that inoculation of patternless leaves is without effect since the cells are already parasitized to the limit (presumably the same limit as the cells of diseased plants).

Studies by Price (80) on virus concentration in recovered plants led to the conclusion that cells of recovered plants are not parasitized to the limit, as Valleau had suggested. It was demonstrated that virus multiplies in the cells of recovered plants but not to the same extent as in recently infected plants grown under the same conditions. The recovered portions of affected plants were found to contain, on the average, only from 10 to 20 per cent as much virus as the diseased portions of the same plants. It should be mentioned in this connection that Stanley (98) isolated a virus protein from recovered plants apparently identical with that obtained from diseased plants, but it was present in only $\frac{1}{8}$ the amount. The line of demarcation between areas of high and low virus titer is very sharp. The healthy-appearing basal portions of partly recovered leaves contain significantly less virus than the diseased apical portions of the same leaves (80). No differences were found between apical and basal portions of either fully recovered or fully diseased leaves. The virus concentration of re-

covered leaves was not apparently increased by inoculating them heavily with ring-spot virus. The observations reported suggest that there is a mechanism by means of which recovered plants restrict the multiplication of ring-spot virus, a mechanism not possessed by healthy or recently infected plants.

In discussing the meaning of acquired immunity, it was stated that the resistance acquired must be specific. Acquired im-

those causing Valteau's (109) green and yellow ring-spot diseases.

Tobacco ring spot No. 2. A second virus disease from which plants recover and acquire immunity is tobacco ring spot No. 2, first described by Price (81). The virus concerned is readily transmitted by mechanical inoculation and induces, in Turkish tobacco, primary and secondary zonate necrotic lesions similar to those of ordinary tobacco ring spot. Sys-



FIG. 2. *NICOTIANA TABACUM* VAR. *PURPUREA* 16 DAYS AFTER INOCULATION WITH RING-SPOT VIRUS

The plant on the left, which shows no symptoms other than the injury produced by rubbing, was grown from a cutting of a plant that had recovered from ring spot. The plant on the right, which shows typical symptoms, was grown from a cutting of a healthy plant. (After Price, 76.) (Photograph by L. P. Flory.)

munity from tobacco ring spot meets this criterion, since tobacco plants that have recovered from ring spot are susceptible to infection by tobacco-mosaic, cucumber-mosaic, potato vein-banding, potato ring-spot, tomato spotted-wilt, etch, and severe-etch viruses and, no doubt, to all other tobacco viruses that are not closely related to ring-spot virus (81). They are immune from or highly resistant to infection by closely related viruses such as

temically infected tobacco plants show recovery characterized by the development of zonate oak-leaf patterns, and by the eventual production of leaves that are entirely symptomless. Leaves of recovered plants harbor the virus of the disease in considerable quantity and they do not develop necrotic-ring symptoms upon reinoculation even when borne on rapidly growing plants propagated by means of cuttings from recovered plants.

Plants that have recovered from tobacco ring spot No. 2 are solidly immune from this disease but are susceptible to infection by viruses of ordinary tobacco ring spot, including the green and yellow strains, and by the viruses of tobacco mosaic, cucumber mosaic, potato vein banding, potato ring spot, tomato spotted wilt, etch, and severe etch. Conversely, plants that have recovered and are immune from ordinary tobacco ring spot, or the green or yellow form of the disease, are readily susceptible to tobacco ring spot No. 2. This observation affords an excellent example of the specificity of acquired immunity from these plant virus diseases.

Tobacco streak. Tobacco-streak disease, first described by Johnson (53), has been known for at least 18 years. It is transmitted readily by mechanical inoculation. The symptoms of tobacco streak consist of necrotic lesions confined entirely to the leaves. The lesions may be either solid necrotic spots, necrotic rings, or necrotic etch-like patterns following along the veins. After systemic invasion, tobacco plants infected with the disease invariably recover by the production of new leaves that do not show necrotic symptoms. Recovered plants carry the virus of tobacco streak and occasionally show clearing-of-veins and mild mottling. The recovery apparently bears no relation to the external environmental conditions. Reinoculation of recovered plants, in contrast to inoculation of healthy controls, fails to produce an attack of the necrosis. Plants that have recovered from tobacco streak are susceptible to infection with tobacco-mosaic, cucumber-mosaic, tobacco ring-spot, potato ring-spot, potato-mottle, and potato vein-banding viruses. Conversely, plants infected with these viruses are still susceptible to infection with tobacco-streak virus (54).

In his first report on tobacco streak,

Johnson (53) suggested that the recovery and subsequent immunity to the typical disease constituted acquired resistance. After making a thorough study of recovery from tobacco streak, he (54) came to the conclusion that the phenomenon was a good example of acquired immunity from a plant virus disease, and suggested that artificial immunization might be used as a practical control measure for virus diseases of vegetatively propagated plants.

Bergerac ring spot of tobacco. A fourth virus disease from which plants recover and probably acquire immunity is Bergerac ring spot of tobacco. The causative virus was isolated at Bergerac in southwestern France by Smith (96, pp. 285-289). Tobacco plants affected by the disease show typical ring-spot symptoms from which they eventually recover, although they still carry virus. Thus, the recovery is similar to that which occurs in the other ring-spot diseases and in tobacco streak. Smith states that no cross immunity exists between Bergerac ring spot, tobacco ring spot, and tobacco ring spot No. 2. He thus implies that plants recovered from Bergerac ring spot are immune from a second attack of this disease, although he does not specifically state this to be the case.

Sugar-beet curly top. The four virus diseases so far considered are similar in producing necrotic ring-spot symptoms. Sugar-beet curly top, on the other hand, is a yellows-type disease characterized by yellowing without the production of discrete lesions. The report by Lesley and Wallace (66) that certain races of tomato (*Lycopersicon esculentum* Mill. and *L. pimpinellifolium* Mill.) recover and acquire immunity from curly top is therefore of considerable interest. This immunity is not of so high an order as in the ring-spot and streak diseases. In-

fectured plants do not always recover; those that recover occasionally show a relapse, and they may, in a few instances, develop severe symptoms when reinoculated.

Young tomato plants infected with curly top late in spring develop the disease in about 12 days. The leaves become rolled, growth is stunted, flowers and buds drop, the fruit colors prematurely, and the plant as a whole assumes a sulphur-yellow color. As a rule the infected plant dies. However, in certain races of tomato, from 10 to 100 per cent of infected plants recover from the disease by production of healthy-appearing shoots from axillary buds. When propagated vegetatively by cuttings, recovered plants are relatively slow-growing and have other mild symptoms of disease. Reinoculation of such plants fails as a rule to produce any further symptoms in them in contrast to the severe symptoms produced in healthy plants propagated from cuttings. No attempts have as yet been made to determine whether the immunity is specific for the curly-top disease. It perhaps should be stated that Lesley and Wallace referred to recovery from curly top in tomato as acquired tolerance, not as acquired immunity. (See the section on "The meaning of acquired immunity.")

Potato yellow dwarf. Another virus disease from which certain species of plants recover and acquire immunity is yellow dwarf of potato. Black (12) has emphasized that there are two distinct phases of the disease in potato (*Solanum tuberosum* L.), an acute stage and a chronic stage. Symptoms of the acute stage have been described in detail by Barrus and Chupp (4). The dwarfed condition of affected plants and their yellow color give the disease its name. Infected stalks are short, become yellowish green in color throughout, and develop internal and

and external necrosis. The growing tip becomes yellowed and necrotic and dies; axillary buds also die, but somewhat later. Tubers produced by diseased plants show various degrees of internal necrosis and are knobby and cracked. The few plants grown by Barrus and Chupp from diseased tubers showed symptoms similar to those which Black (12) attributes to the chronic stage of yellow dwarf. The chronic stage is found in plants that have recovered by production of new growth from axillary buds (Fig. 3). Such new growth, besides being somewhat dwarfed and spindling, also shows clearing-of-veins and a mild mottling. However, the uppermost leaves do not yellow and die as in the acute stage. Recovered plants, furthermore, do not develop the severe internal apical necrosis characteristic of the onset of the disease. Recovered plants have been grown through five vegetative generations without again developing acute symptoms of yellow dwarf. Recovery from yellow dwarf occurs regularly and is not due to special environmental conditions or to attenuation of virus. Although Black did not specifically refer to this recovery as acquired immunity, he pointed out that the pathogenic activity of the virus was checked by a change within the plant. It is clear that he believed an increased degree of resistance was elicited. A similar type of recovery was observed in medium red clover (*Trifolium pratense* L.) and crimson clover (*T. incarnatum* L.) plants infected with potato yellow dwarf (12, 13).

Other diseases. There may be many other diseases, besides those already mentioned, in which plants normally recover and become immune from a further attack. Johnson (54) has, in fact, suggested that the presence of potato ring-spot and potato-mottle viruses in all

standard varieties of American potatoes without the production of symptoms may be due to an acquired immunity on the part of the potato. Before this conclusion can be accepted, it will be necessary to determine whether potatoes infected with the virus for the first time develop a disease from which they later

instance, Nishimura (73) reported *Physalis alkekengi* L. to be a masked carrier of tobacco-mosaic virus. However, as pointed out by Holmes (42), *P. alkekengi* occasionally shows mottling symptoms. In the tip leaves of symptomless plants, virus, if not completely absent, is present only in low concentration, but in mottled



FIG. 3. A GREEN MOUNTAIN POTATO PLANT INFECTED WITH YELLOW DWARF

The main axis shows severe symptoms of the acute stage. The axillary shoot shows progressive recovery to the chronic stage. (After Black, 12.) (Photograph by W. R. Fisher.)

recover. For it is possible that infection of the original potato stock resulted in no symptoms whatever. There are numerous instances of plants being infected by viruses without the production of symptoms. Such plants are usually referred to as "masked" or "symptomless" carriers. They may not remain symptomless under all environmental conditions. For

leaves is present in high concentration. This implies that failure to produce symptoms results from a failure of virus to multiply extensively in very young growing tissues.

Tomato plants inoculated with the Y virus develop clearing-of-veins and other mild symptoms of disease. The mild symptoms rapidly disappear and the plant

then carries the virus without showing further symptoms (90). Smith (92) compared the recovery from the disease produced by potato-Y virus with that which occurs in tobacco plants infected with ring-spot virus and suggested that it constituted acquired immunity though not in the usual conception of the term. There are a number of other virus diseases from which certain species of plants show a similar type of recovery. Köhler (57) described such recovery in tobacco plants infected with a mixture of potato X and Y viruses. Whether such cases as the two here mentioned can properly be regarded as acquired immunity is open to question and must await further study. At the present time it is not known whether the recovery is more than a masking of symptoms brought about by aging of the host plant.

Symptoms of certain virus diseases, such as tobacco mosaic and cucumber mosaic in tobacco, are at first severe, but the onset stage of the disease is followed by the production of a whorl of leaves that are either healthy in appearance or show only mild symptoms. The escape of these leaves may be due either to slow spread of virus or to a change in susceptibility of the host tissue. If it is an immune reaction, it is of a relatively low order, since subsequently produced leaves show mottling symptoms and the recovery is thus only a temporary one. Comparison of virus concentration in the leaves produced before and after the recovery might reveal whether or not the virus activity is checked and might thus be of value in arriving at an understanding of this phenomenon.

CROSS IMMUNITY

Virus strains. Before taking up in detail the second type of acquired immunity from plant virus diseases, it might

be well to digress for a moment to examine what is meant by virus strains and how they arise. In the early days of plant virus research, it was a common belief that one virus was the cause of many, if not all, virus diseases of plants—that there was one mosaic disease that attacked a great variety of plants. Thus, as late as 1925, Elmer (32) spoke of transmissibility and pathological effects of the mosaic disease as though there were only one such disease. As new experimental evidence became available, however, it came to be recognized that more than one virus was involved in the many mosaic diseases of plants; that, for example, tobacco mosaic would attack certain plants but not others; and that these others were often affected by mosaic diseases that differed from tobacco mosaic. This recognition led to a search for new viruses and to a propensity among phytopathologists to ascribe a new virus to each new virus disease discovered. Thus there developed a tendency for differentiating between viruses on minor symptom or host range differences—and this tendency persists to a limited extent even to the present day. Gradually, however, it was realized that there are groups of viruses, each markedly different from other groups but made up of strains very much alike in some respects and differing slightly in others. At first, viruses were grouped on the basis of their physical properties, such as resistance to heat, aging, and various chemicals, their host range, and their transmission by insect vectors. Although it is still necessary to use such criteria for differentiating and classifying many plant viruses, more exact methods are available for others. Two of the most important methods in use today are the serological method developed by Dvorak (29), Beale (7), Matsumoto (68), Silberschmidt (89), Birkeland (11), Chester

(20), and others, and the plant cross immunity tests which will be dealt with below in considerable detail.

Virus strains belonging to various groups have been recognized in nature and have also been obtained under experimentally controlled conditions. For instance, attenuated strains of sugar-beet curly-top virus have been secured by passage of the virus through resistant varieties of sugar beets or through resistant weed hosts (17, 18, 64, 65) and attenuated strains of tobacco-mosaic virus by incubation in host tissues at relatively high temperatures (51, 43, 58). Mild strains of aster-yellows virus were isolated from the insect vector when colonies of the vector were maintained at high temperatures (61, 62). Various strains of tobacco-mosaic virus have been isolated from bright yellow spots that appear in tomato plants infected with ordinary tobacco mosaic. (McKinney (69) was the first to show that yellow-mosaic viruses may be isolated by subinoculation from yellow spots, and he (70) suggested the possibility that these viruses arise by mutation from the ordinary strain. He (71) also found that a yellow-mosaic virus may be obtained in a similar manner from wheat (*Triticum aestivum* L.) plants infected with ordinary wheat mosaic. Jensen (46, 47) found that variant strains arise during multiplication of ordinary tobacco-mosaic virus in infected plants, apparently by a process similar to mutation. Virus of tobacco mosaic freed from all other viruses by serial passage through the necrotic primary lesions it produces in *Nicotiana glutinosa* L. subsequently gave rise to variant strains when transmitted to plants in which it became systemic. Virus purified by several other methods was likewise found eventually to produce mutant strains. A total of 51 such strains were isolated and studied by

Jensen (46, 47, 48). The number has been considerably augmented by later studies (44, 74).

It is probable that mutations occur not only in tobacco-mosaic virus but also in most if not all, plant viruses. They have been shown to occur, for instance, in cucumber-mosaic virus (77, 39). It thus seems likely that many of the virus strains existing in nature have arisen, at some time in the past, by mutation from some other virus and that these virus strains may be classified into groups the members of each of which are genetically related (59).

Demonstration of cross immunity. The first indication that one strain of a virus might protect plants from infection with another strain was an observation by McKinney (70) in 1929. He found that when tobacco plants infected with a light-green-mosaic virus were inoculated with a yellow-mosaic virus, no change in symptoms occurred. However, plants infected with a mild-dark-green-mosaic virus developed yellow-mosaic symptoms when inoculated with the same yellow-mosaic virus. It appears unlikely that McKinney regarded the protection by the light-green-mosaic virus as acquired immunity, for he merely mentioned the experiment casually and did not report any further study of the matter. Later writers were apparently unaware of McKinney's observation, as no further reference to it has been found in the literature.

From ordinary tobacco-mosaic virus, Thung (104) isolated a yellow-mosaic virus similar to McKinney's (70) yellow-mosaic virus and Johnson's (52) tobacco virus 6. Plants infected with ordinary mosaic developed no change in symptoms when inoculated with the yellow-mosaic virus. Similarly, plants infected with yellow mosaic developed no change in symptoms when inoculated with the

ordinary mosaic virus. Moreover, only one virus could be isolated from the doubly inoculated plants, the one first introduced. These results led Thung to conclude that only one of the two virus strains could multiply extensively in any given cell.

Following Thung's original studies, Salaman (85) made similar experiments with strains of the potato-X virus. By subinoculating from green and yellow areas, respectively, of a tobacco leaf affected by the X virus, he obtained two strains—an exceedingly mild type (G) and a severe yellow type (L). Plants infected with the mild G type, whether showing definite symptoms or not, were protected from subsequent infection with the severe L-type virus. Salaman concluded that plants with the L strain had acquired immunity from the G strain. The immunity developed on the 5th day after inoculation and about 4 or 5 days before systemic symptoms of the G strain appeared. It seemed to be specific, since it was effective against other strains of the X virus but not against the potato-Y virus or the common tobacco-mosaic virus.

Oortwijn Botjes (75) showed that plants of certain potato varieties infected with either secondary top necrosis or attenuated top necrosis are, as a rule, protected against primary top necrosis, a more virulent disease. The viruses concerned in this work are probably identical with, or closely related to, those used by Salaman (85), since it is stated by Oortwijn Botjes that the virus of top necrosis is known in America as the healthy-potato virus which in turn is known to be the same as, or a strain of, the X virus of English workers. The results of Oortwijn Botjes and Salaman were confirmed by Köhler (57) who reported that both tobacco and potato infected with one

strain of potato-X virus were protected from infection with another strain of potato-X but not from infection with potato-Y virus.

Kunkel (58) made a thorough study of acquired immunity with tobacco- and aucuba-mosaic viruses in *Nicotiana sylvestris* Spegaz. and Comes. In many tests, mature mottled leaves of plants systemically infected with ordinary tobacco-mosaic virus or with either of two attenuated strains of aucuba-mosaic virus were immune from a necrotic-type aucuba-mosaic virus. The protection afforded was very striking, since control plants inoculated with aucuba-mosaic virus came down with numerous necrotic lesions, whereas no such lesions developed in mottled leaves. Subinoculations from mottled leaves that were rubbed with aucuba-mosaic virus failed to demonstrate the presence of the necrotic-type virus. Mature leaves became immune from aucuba-mosaic virus within 2 days after they had been rubbed with attenuated virus (Fig. 4). In order to protect completely against aucuba-mosaic virus, it was necessary to inoculate heavily with attenuated virus so that all parts of the leaves became infected. No evidence was obtained that tissues free of virus, whether or not adjacent to virus-infected tissues, became immune. However, local protection was not confined to cells actually inoculated; inoculation of the lower surface of a leaf was capable of protecting the leaf from infection by a subsequent inoculation of the upper surface, although 5 cell layers intervene between the upper and lower epidermal cells. Acquired immunity from aucuba mosaic is specific. Protection was afforded by previous infection with all strains of tobacco- and aucuba-mosaic viruses tested, but not by previous infection with cucumber-mosaic or tobacco ring-spot viruses.

Interesting examples of acquired immunity from strains of tobacco-mosaic virus have recently been reported by Kunkel (63). A mild strain of tobacco-mosaic virus, designated as V-9, was used to immunize *Nicotiana sylvestris* plants completely from a lethal strain, J-111, which invariably causes the death of unprotected *N. sylvestris* plants. Strain V-9 was also used to immunize tomato plants from infection with strain J-14D, a virus which quickly kills normal tomato

that mottled leaves of plants infected with any one of 4 different strains of cucumber-mosaic virus became immune from infection with a necrotic-type strain. They were, however, susceptible to a necrotic-type tobacco-mosaic virus. Furthermore, zinnia plants infected with tobacco mosaic, aucuba-mosaic, tobacco ring-spot, yellow-ring-spot, or severe-etch virus did not acquire immunity from the necrotic-type cucumber-mosaic virus. The immunity induced in zinnia by cucumber-

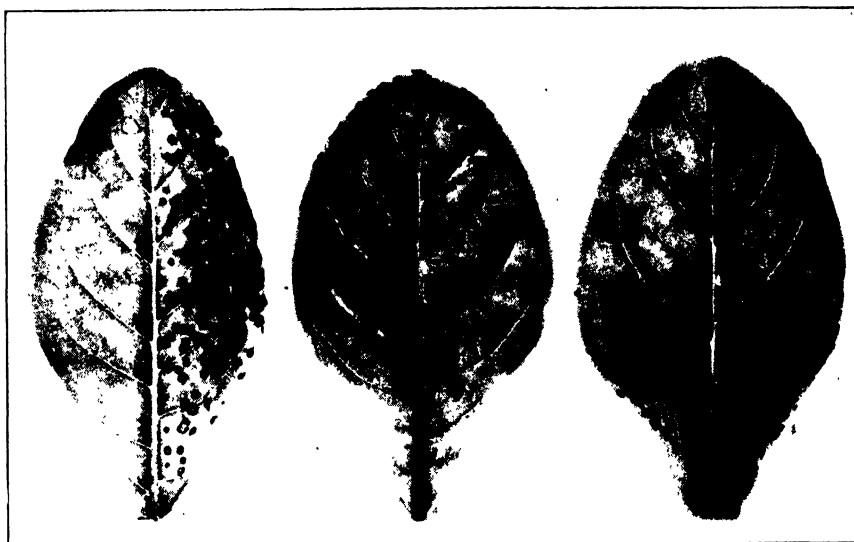


FIG. 4. LEAVES OF *NICOTIANA SYLVESTRIS* SHOWING NECROTIC LESIONS PRODUCED BY AUCUBA-MOSAIC VIRUS

The lesion-free areas were immunized by inoculating them heavily with tobacco-mosaic virus 5 days before the entire leaf surfaces were rubbed with aucuba-mosaic virus. (After Kunkel, 58.) (Photograph by J. A. Carlile.)

plants to which it is transmitted. Interestingly enough, tomato plants were saved from death or serious injury when they were inoculated with the protecting virus, V-9, within 3 days after they had become infected by J-14D. They could not be saved in this manner if they had been infected with the lethal virus for longer than 3 days.

Acquired immunity of *Zinnia elegans* Jacq. from cucumber mosaic has been studied by Price (78). It was found

mosaic virus was thus shown to be highly specific.

The cross immunity reactions discussed so far have been concerned with viruses readily transmitted by mechanical inoculation. The immunological studies by Kunkel (60) on the yellows, rosette, and little-peach diseases of peach (*Prunus persica* Sieb. and Zucc.) are of special interest because these diseases are transmitted only by insects or by grafting. All 3 diseases cause stunting, the abnormal

production of secondary shoots, and yellowing of mature leaves. Little peach is the least severe of the 3, rosette the most severe. Kunkel has shown that peach trees having the little-peach disease are solidly immune from yellows. Similarly, trees infected with yellows are

to a tree affected by little peach and allowed to grow, the bud not only failed to transmit the yellows disease but also produced shoots which invariably came down with little peach. Similarly, little-peach buds transplanted to yellows trees produced shoots which developed yellows.

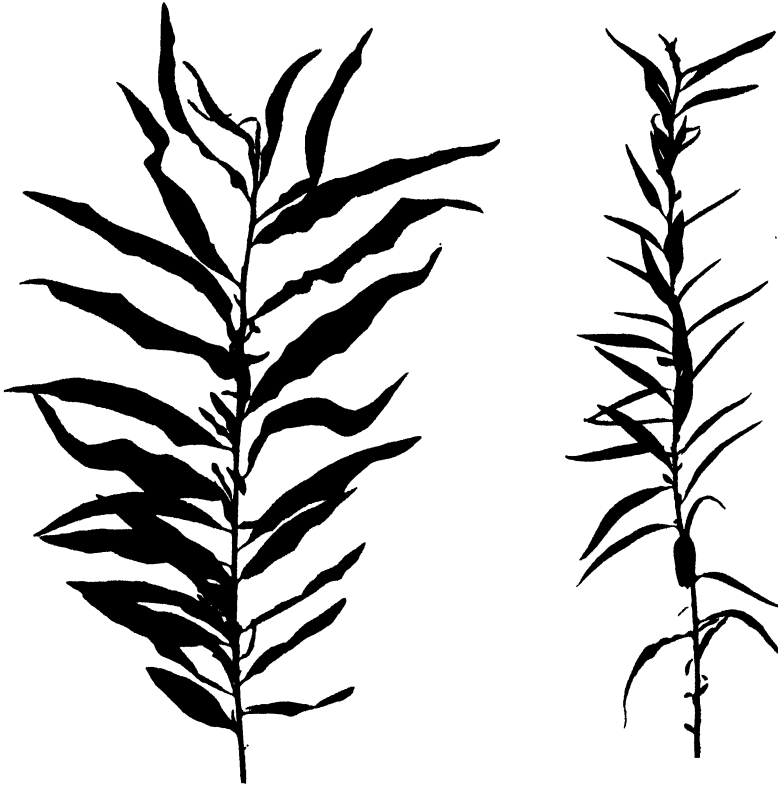


FIG. 5. PEACH TREE SHOOTS THAT GREW FROM TRANSPLANTED BUDS

The shoot on the left was from a yellows bud that grew in a little-peach tree; it shows the mild leaf distortion symptoms characteristic of little peach. The shoot on the right was from a little-peach bud that grew in a yellows tree; it shows characteristic yellows symptoms. Both shoots have developed symptoms of the disease present in the tree regardless of the virus carried in the bud. (After Kunkel, 60.) (Photograph by J. A. Carlile.)

immune from little peach. On the other hand, trees having either yellows or little peach are fully susceptible to rosette. All the immunity tests were made by insertion of one or more diseased buds into the stem of the tree to be tested. When a bud from a yellows tree was transplanted

In other words, shoots from the transplanted bud developed the symptoms of the disease present in the stock, regardless of the virus carried in the bud (Fig. 5). Similar results were obtained even though the transplanted buds were removed from the diseased tree before they produced

shoots and were transferred to a healthy tree. When little-peach and yellows buds were inserted simultaneously at different levels into stems of healthy trees, the trees developed symptoms of the virus carried by the bud at the higher level. These results led Kunkel to suggest that under suitable conditions either the yellows or little-peach virus is capable of displacing the other in infected tissues. The means by which the displacement takes place is not known. Kunkel states that it apparently cannot be due to mass action, since approximately equal doses of the viruses are involved when two buds are transplanted to a tree on the same date.

Use of plant protection tests in differentiation and classification

The cross immunity reaction is extremely useful for differentiating and classifying plant viruses. It has been used for classifying viruses belonging in the potato-X virus group (85, 75, 1, 54), the tobacco-mosaic virus group (104, 105, 58, 93, 16), the cucumber-mosaic virus group (78), the tobacco ring-spot virus group (81), and the potato-Y virus group (87), among others. Price (81) used it to differentiate between tobacco ring spot No. 2 and other viruses. Immunity studies by Kunkel (60) showed that peach-yellows and little-peach viruses are related to each other but not to peach-rosette virus.

Bawden (5) found that potato-X virus and potato-D virus, which causes foliar necrosis in the potato, usually gave complete cross protection in tobacco, potato, and *Datura stramonium* L. He was thus led to suggest that potato-D virus might be classified in the potato-X virus group.

The mosaic disease of celery (*Apium graveolens* L.) first observed in Florida

about 1924 (33) and later studied extensively (27, 28, 112, 113, 114) was thought to be distinct from, although similar to, ordinary cucumber-mosaic virus. Cross protection tests with southern-celery-mosaic virus in *Zinnia elegans* showed it to belong to the cucumber-mosaic virus group, a fact confirmed later by other lines of evidence (79).

The lily-mosaic disease has been known since the turn of the century (99) and was probably introduced into Bermuda about 1893 (116) where it caused a rapid decline in the lily (*Lilium* spp.) industry of the island. Cross protection tests have shown this disease to be induced by a virus belonging in the cucumber-mosaic virus group (82, 2). However, Brierley (14) has recently brought evidence that lily mosaic is caused by the interaction of two viruses, one of which is related to cucumber-mosaic virus and the other is similar to the color-removing virus of the tulip-mosaic virus complex (72).

Smith (94, 95) used plant protection tests as a means of differentiating between the virus of a new disease of tomato, now called bushy stunt, and the viruses of tobacco mosaic, tomato spotted wilt, tobacco ring spot, and Bergerac ring spot. He (96, pp. 285-289) also differentiated between the viruses of Bergerac ring spot, tobacco ring spot, and tobacco ring spot No. 2 by their failure to cross immunize.

Bald (3) used plant protection tests for differentiating between an F-type potato virus occurring in Australia and the Y, X, and a mixture of X and B viruses of potato. Bawden (6) found that potato plants infected with the X virus were not protected from infection when grafted with scions carrying both the X and B viruses. He was thus led to conclude that the B virus is probably distinct from the X virus. Dennis (26) recently separated the B virus from the mixture and

found that it gave no cross protection against potato-X virus in either *Datura stramonium*, potato, or tobacco. Since the X and B viruses have similar host ranges and almost identical properties so far as known, and since they can not be distinguished serologically, Dennis maintains that it is only because they do not show complete cross protection that they are believed to belong in different groups.

Storey (100) described a new virus of maize (*Zea mays* L.), which he calls the mottle virus. The results of immunity studies led him to conclude that the mottle virus is not related to the virus of maize-streak disease even though both viruses are transmitted by the same species of *Cicadulina*.

Price (83) made use of cross immunity tests to demonstrate that tobacco-necrosis virus, first described by Smith and Bald (97), is not related to tobacco ring-spot, tobacco ring-spot No. 2, tobacco-mosaic, cucumber-mosaic, or severe-etch viruses.

Dykstra (30, 31) used plant protection tests for differentiating between and classifying certain potato viruses. On the basis of these tests, he concluded that the European Y, the American vein-banding, and the potato stipple-streak viruses are interrelated, but not related to cucumber-mosaic virus, nor to the virus complex causing Di Vernon top necrosis, and that pseudo net-necrosis virus from Holland, tuber-blotch virus from Ireland, potato aucuba-mosaic virus, and Canada-streak virus are closely interrelated but not related to potato-calico virus.

Virus relationships as determined by plant protection tests are generally in accord with those determined by the serological method (8, 9, 20, 21, 23). In a few instances, however, some differences have been observed. For example, Chester (22) has shown that certain viruses,

while having antigens in common and known to be closely related, nevertheless show minor serological differences. Furthermore, Chester (23) obtained cross-serological reactions between ordinary tobacco ring-spot and tobacco ring-spot No. 2 viruses, whereas no such cross reaction has been found by means of plant protection tests (81). The reason for these differences is not clear. In the first case mentioned, i.e., the serological differences between virus strains, it would appear that the serological method is more sensitive than the plant protection method, whereas in the second case the plant protection method would seem to be more sensitive. Virus relationships based on plant protection tests also agree reasonably well with those determined by symptomatology, host range, physical properties, and insect vectors.

*Reliability of plant protection tests for
determining virus relationships*

It may be asked at this point: how reliable are plant protection tests for determining virus relationships? The evidence we have already considered favors the view that a plant cell infected with one strain of a virus cannot subsequently become infected with another strain of the same virus. It also supports the conclusion that a cell already infected will allow infection with, and multiplication of, unrelated viruses. From this it follows that, if one virus protects a plant from infection with another, the two viruses are doubtlessly related, and, conversely, if a virus does not protect cells from infection with a second virus, the two are probably unrelated. What, then, are the possible sources of error in practical application of cross protection tests? The reliability of the method would seem to depend, for the most part, upon the accuracy with which it can be determined

whether or not one of the two viruses, whose relationship is under question, is able to multiply in cells already occupied by the other virus. The accuracy with which such a determination can be made may become clear by consideration of two different types of protection tests.

The two types referred to are fundamentally alike—they differ only in that one depends upon evidence of systemic, the other upon evidence of local infection. Let us suppose that the two viruses under consideration are of the mosaic type, and both capable of producing systemic symptoms in a susceptible host. Let us assume further that one of the viruses is of the green-mosaic and the other is of the yellow-mosaic type. Plants are infected with the green-mosaic virus and allowed to become thoroughly mottled. They are then inoculated with the yellow-mosaic virus. If, after a suitable interval, yellow-mosaic symptoms have not developed in the infected plants but have developed in suitable controls inoculated with the same yellow-mosaic virus at the same time, it is reasonably safe to conclude that the green mosaic has protected the plant from infection with the yellow mosaic and that the two viruses are therefore closely related. If, on the other hand, the plant develops yellow-mosaic symptoms in addition to those of green mosaic, it is not so safe to conclude that the two viruses are unrelated. It is possible that the yellow-mosaic virus may have infected the plant through cells not actually invaded by the green-mosaic virus. A number of cells of a mottled leaf may be virus-free, although the majority of cells are infected. For example, it has been shown (40, 37) that in a leaf mottled by tobacco-mosaic virus, the yellow areas have a high concentration of virus whereas the green areas contain relatively little virus, and it is presumed that some of the cells of

such areas are entirely free of virus. Such cells are probably susceptible to infection with another strain of tobacco-mosaic virus, for it has been shown by Kunkel (58) that only those areas actually invaded by a mottling strain of tobacco-mosaic virus are immune from infection with a necrotic-type strain—uninvaded areas are susceptible even though adjacent to infected tissue. Johnson and Valteau (49) have presented evidence to show that, if plant tissue is incompletely invaded by a mild strain of tobacco-mosaic virus, another strain of the virus can enter, multiply, move to the incompletely invaded tissue of the growing point, and eventually produce symptoms in the tip of the plant. Similarly, Holmes (43) has shown that a masked strain of tobacco-mosaic virus does not protect tobacco plants from systemic infection with a distorting strain, although it delays movement of the distorting strain and, hence, appearance of systemic symptoms. Further evidence bearing on this point is contained in the report by Bawden (5) that tobacco plants systemically infected with potato-D virus occasionally developed a few necrotic rings when subsequently inoculated with potato-X virus. By subinoculation from such rings, the X virus was obtained free from the D virus. This led Bawden to conclude that the areas in which the X virus had produced symptoms contained none of the D virus. In the case under discussion, infection of virus-free areas with yellow mosaic could conceivably be followed by systemic invasion. The actual number of infections would not have to be large—two or three primary infections will give rise to systemic symptoms almost, but not quite, as rapidly as several hundred primary infections (41). In plant protection tests based on appearance of conspicuous systemic symptoms, it may be concluded

that a positive protection is indicative of virus relationship but that negative results are not entirely satisfactory for differentiating between two viruses.

Protection tests based on evidence of local infection are considerably more satisfactory. Multiplication at the site of inoculation may be detected by the production of yellow or necrotic primary lesions or by subinoculations to a host plant that will allow the two viruses under test to be distinguished. Both methods may be illustrated with tobacco- and aucuba-mosaic viruses in *Nicotiana sylvestris* (58). When a leaf thoroughly mottled by tobacco mosaic is inoculated with aucuba-mosaic virus, no lesions develop, but if a leaf mottled by an unrelated virus, such as cucumber-mosaic virus, is likewise inoculated with aucuba-mosaic virus, a large number of lesions develop. The production of lesions is evidence that multiplication has occurred. Additional evidence that virus multiplication has or has not occurred can be obtained by subinoculation to healthy *N. sylvestris* plants. Since tobacco-mosaic virus does not produce necrotic lesions in this plant, the development of such lesions indicates presence of aucuba-mosaic virus and the failure to develop lesions, absence of the virus. It is thus seen that plant protection tests based on evidence of virus multiplication at the site of inoculation may furnish conclusive evidence not only that two viruses are related but also that other viruses are unrelated. Such tests are therefore much superior to those involving only systemic symptoms. Since viruses that produce distinctive primary lesions are required for use in the former type of test, it would seem desirable to search for representative virus strains that possess this characteristic. Examples of virus groups comprising both mottling-type and necrotic-type

viruses are the tobacco-mosaic, cucumber-mosaic, and potato-X virus groups. Undoubtedly, other such groups will be found when sufficiently exhaustive studies have been made.

What has been said here need not discourage plant protection tests in virus groups which, so far as known, do not contain strains that produce readily detected primary lesions. Such tests may be quite useful; indeed, they have already proved useful in certain cases (60). It should be borne in mind, however, that failure to obtain cross protection between mottling-type viruses may indicate failure of the viruses to become completely systemic rather than a lack of relationship between them.

THE MECHANISM INVOLVED IN ACQUIRED IMMUNITY FROM PLANT VIRUS DISEASES

Practically nothing is known regarding the mechanism responsible for acquired immunity from plant virus diseases. Any theory that is suggested to explain the condition is, therefore, highly speculative. Certain hypotheses have been formulated, however, and it seems worthwhile to discuss briefly some of these suggestions.

In recovery of tobacco plants from the ring-spot disease, there is apparently a mechanism for limiting virus production to a level considerably below that present in plants during the onset stage of the disease (80). Although the exact nature of the mechanism is unknown, the discovery of the difference in virus concentration led to the formulation of the following hypothesis (80). Ring-spot virus is able to reach its maximum concentration in, and to exert its maximum effect upon, only those cells that are nearly mature at the time of invasion. Invasion of embryonic cells of tobacco plants is not accompanied by maximum increase

in virus nor by severe injury to the cells. Having once been invaded, the embryonic cells become adapted to the presence of virus and maintain an equilibrium with it. Symptoms are produced in tobacco plants just as long as the growing point has not been invaded. Once the embryonic cells become infected, the plant recovers. This hypothesis is supported by the fact that the onset stage of the disease may be prolonged or shortened by exposure of infected plants to good or poor growing conditions (76) which, presumably, increase or decrease the time required for the virus to reach the growing point. Whether or not the hypothesis is correct, it still does not reveal the fundamental nature of the mechanism involved.

Thung (105) has suggested that virus-infected plants, like animals, develop immunizing substances which neutralize or tend to neutralize the virus in the plant. Such substances have not yet been demonstrated. The hypothesis that they may play an active part in acquired immunity from plant virus diseases therefore awaits experimental proof.

A simple explanation for cross immunity in plants may be based on the assumption that certain protoplasmic constituents, such as, perhaps, specific amino acids, are essential for virus reproduction. It is conceivable that one virus in a plant may exhaust the supply of material essential for reproduction of that particular virus and thus render the invaded cell immune from a closely related virus that requires the same material. Other unrelated viruses, however, might require entirely different materials which would not be utilized by the first virus. The cell would, therefore, still be just as susceptible as a virus-free one. Essentially this hypothesis was suggested as a possibility by Kunkel (58), by Köhler (57), by Bawden

(5), and by Salaman (86). While the hypothesis may serve to explain the chronic-disease type of acquired immunity, it does not explain the carrier type in which the virus concentration of recovered tissue is considerably lower than that of diseased tissue; it must be inferred that, in this type, either the essential material has not been entirely used up or its production by recovered plants has been sharply curtailed. Furthermore, it has been pointed out by Kunkel (58) that, although the dark green areas of leaves mottled by tobacco mosaic contain less virus than the yellow areas, they are nevertheless immune from aucuba mosaic.

It seems apparent that present theories are inadequate to account for acquired immunity from plant virus diseases. It is possible that some mechanism entirely different from those mentioned is involved. A satisfactory solution to the problem must await further discoveries in plant virus immunity.

COMPARISON OF ACQUIRED IMMUNITY IN PLANT AND ANIMAL VIRUS DISEASES

Plants have not been shown to acquire *passive* immunity from virus diseases. The reasons for this seem fairly obvious. In the first place, plants are not known to develop antibodies or immunizing substances against viruses. Moreover, even if such substances were known, the absence in plants of a circulatory system comparable to that of animals would seem to make it extremely difficult if not impossible to obtain thorough spread of such substances from a single injection in healthy plants. The role of antibodies in animal virus acquired immunity is not well understood. It is possible that their function is only secondary, since an animal may show a solid immunity in the absence of demonstrable antibodies or may be susceptible in the presence of large

amounts of antibodies (118). The apparent absence of antibodies in plant virus immunity should not, therefore, necessarily distinguish between acquired immunity in plant and animal virus diseases.

Acquired immunity from plant virus diseases is, so far as known, of the non-sterile type. In a number of virus diseases of animals, acquired immunity following recovery from disease is accompanied by apparent disappearance of the disease agent; at least in some diseases the virus has not been detected in recovered animals by ordinary methods. Retention of virus in plant tissues that have become immune from virus diseases indicates that the immunity is cellular rather than humoral. Because it appears to be cellular, Salaman (86) suggested that its nature is essentially different from that exhibited by animals. This may, indeed, be true. However, a distinction made solely on the basis of retention of virus is apt to be misleading, for there are many cases of non-sterile acquired immunity in animal diseases. For example, Cole and Kuttner (24) were able to obtain virus from the submaxillary glands of guinea pigs that were immune from the effects of the virus introduced elsewhere in their bodies and to show that the same virus was often lethal for guinea pigs that had not previously been infected. Koch (56) showed that virus was present in the blood of horses as long as 7 years after an attack of infectious anemia. In this case, recovered horses are not completely immune, since they may sometimes suffer a relapse. Theiler (103) has reported that horses frequently carry virus of African horse-sickness for as long as 90 days after recovery. In contagious epithelioma of fowls, virus can be obtained from certain organs as long as 4 weeks after complete recovery from the skin eruption, although the recovered birds

have a strong active immunity to cutaneous infection (67, 88).

It has been shown by Traub (107, 108) that mice clinically recovered from choriomeningitis frequently carry virus in their blood for several weeks or months. Such mice have a high degree of immunity, while mice that have never had the disease are always killed by intracerebral injection of choriomeningitis virus. Clinically recovered mice no longer carrying detectable amounts of virus in the blood often show an incomplete immunity to intracerebral injection. Traub concludes that the immunity of carrier mice probably is not due to protective antibodies but that it may be tied up in some manner with infected tissues.

According to Zinsser, Enders, and Fothergill (118), it is probable that, in individuals who have recovered from herpes and have acquired a general immunity from the disease, the virus remains latent in special tissues and gives rise to another attack following injury to certain body cells. Other instances, cited by Zinsser, Enders, and Fothergill, of retention of virus in immune animals are foot-and-mouth-disease virus in hoofs of recovered cattle, poliomyelitis virus in the nasal secretions of a child after recovery from a second attack, virus 3 in a transplanted neoplasm and metastases therefrom in a rabbit that had become immune, vaccinia virus in a rabbit 22 days after establishment of cutaneous immunity, and spontaneous-encephalitis virus in the cords of mice almost a year after recovery.

Recovery from diseases produced in man and lower animals by filterable viruses is, in many diseases, followed by lasting immunity. Because the immunity is lasting, the possibility that it is associated with the persistence of virus has been suggested (84, 117, 118). The failure to demonstrate virus after recovery from

some virus diseases may be due to the presence of antibodies that render the virus noninfectious. That such might be the case is suggested by the tendency of virus to disappear from the blood of rhesus monkeys infected with yellow fever long before the disease has run its course. According to Hudson and Philip (45), virus may be detected in infected monkeys within 12 hours after inoculation and is present in high concentration up to the 5th day following infection. Beginning on the 5th day, the virus decreases in concentration, and it may completely disappear from the blood stream a day or more before the monkey dies from a fatal infection. It appears unlikely that virus actually disappears from the blood before termination of the disease. It seems more likely that virus is still present but is neutralized by antibodies that have developed as a result of the infection. This view is supported by the fact that monkeys inoculated with as much as 5.0 cc. of blood from a 5-day or older case of yellow fever developed mild symptoms and recovered, whereas monkeys inoculated with only 0.5 cc. of the same blood succumbed to a fatal attack, thus suggesting that sufficient antibodies were present in 5 cc. of blood to partially immunize the monkeys against yellow fever.

The situation in equine encephalomyelitis seems to be somewhat similar to that in yellow fever. Although virus may be readily detected during the febrile period, it has never been demonstrated in the blood of horses showing symptoms of the disease. TenBroeck, Hurst, and Traub (102) measured the virus titer in the blood stream of an experimentally infected horse. The virus reached its highest level 3 days before definite symptoms were evident, decreased rapidly, and could not be detected 24 hours before symptoms appeared or thereafter. These workers

cite evidence for their belief that this behavior is typical for field cases of the disease.

In view of the facts that have been stated above, there appears to be little reason for assuming that acquired immunity from plant virus diseases is fundamentally different from that which obtains in animal virus diseases. Whether or not such a difference exists can not be told until more is learned of the fundamental nature of the condition in both animals and plants. Some workers (91, 57) have suggested that the term "acquired tolerance" would be more appropriate than the term "acquired immunity" in connection with the phenomena observed in certain plant virus diseases. There is considerable justification for such a viewpoint. The same suggestion might be made for the many incomplete immunities induced in animals. There seems to be no good reason for setting acquired immunity in plants apart from acquired immunity in animals, and it is therefore felt that the latter term should be retained, at least for the present.

SUMMARY

The evidence reviewed in this paper supports the conclusion that actively acquired immunity from plant virus diseases has been satisfactorily demonstrated. In contrast, passively acquired immunity has not been demonstrated. Immunity that follows recovery from certain plant virus diseases is of the carrier type. Cross immunity, or the inhibition of virus development in a plant cell already infected with a closely related virus, may be either of the carrier or chronic-disease type.

There are at least six different virus diseases in which recovery from the disease is followed by immunity from a second attack, namely, tobacco ring spot,

tobacco ring spot No. 2, tobacco streak, and Bergerac ring spot, all in tobacco (*Nicotiana tabacum* L.), sugar-beet curly top in certain races of tomato (*Lycopersicon esculentum* Mill. and *L. pimpinellifolium* Mill.), and potato yellow dwarf in potato (*Solanum tuberosum* L.). The characteristic features of the immunity are similar for all six diseases. Plants recover after an acute attack by production of shoots or leaves which appear healthy or show only mild symptoms of disease, which still harbor virus, and which are refractory to infection with the virus in question but not to infection with unrelated viruses. It was suggested that there may be other plant virus diseases besides those mentioned in which similar recovery occurs, and it was pointed out that the partial recovery exhibited with numerous other plant virus diseases may or may not be expression of an immune reaction.

With respect to cross immunity, it has been shown with numerous groups of

viruses that plant tissues invaded by one strain of a virus are protected from infection with another strain of the virus but are susceptible to infection with unrelated viruses. The immunity appears to be closely associated with presence of virus in the immune tissues, since there is no evidence that virus-free tissues of infected plants are immune. The cross immunity reaction has proved useful for differentiation and classification of plant viruses. The reliability of its use for this purpose has been discussed in some detail.

There is at present no basis for determining whether or not acquired immunity from plant virus diseases is fundamentally different from that obtaining in animal virus diseases. The hypotheses that have been advanced to explain the possible mechanism of acquired immunity from plant virus diseases are apparently inadequate.

LIST OF LITERATURE

- (1) AINSWORTH, G. C. A comparison of certain English and Canadian potato viruses found infecting tomatoes. *Ann. Appl. Biol.*, 21: 581-587. 1934.
- (2) ——. A note on certain viruses of the cucumber virus 1 type isolated from monocotyledonous plants. *Ann. Appl. Biol.*, 25: 867-869. 1938.
- (3) BALD, J. G. An F-type potato virus in Australia. *Nature*, 139: 674. 1937.
- (4) BARRIS, M. F., and C. C. CHUFF. Yellow dwarf of potatoes. *Phytopath.*, 12: 123-132. 1922.
- (5) BAWDEN, F. C. Studies on a virus causing foliar necrosis of the potato. *Proc. Roy. Soc. London, B*, 116: 375-395. 1934.
- (6) ——. The viruses causing top necrosis (acronecrosis) of the potato. *Ann. Appl. Biol.*, 23: 487-497. 1936.
- (7) (BRALE) PURDY, H. A. Immunologic reactions with tobacco mosaic virus. *Jour. Exp. Med.*, 49: 919-935. 1929.
- (8) BRALE, H. P. Specificity of the precipitin reaction in tobacco mosaic disease. *Contr. Boyce Thompson Inst.*, 3: 529-539. 1931.
- (9) ——. The serum reactions as an aid in the study of filterable viruses of plants. *Contr. Boyce Thompson Inst.*, 6: 407-435. 1934.
- (10) BENNETT, C. W. Viruses diseases of raspberries. *Mich. Agr. Exp. Sta. Tech. Bull.*, 80. 38 pp. 1927.
- (11) BIRKELAND, J. M. Serological studies of plant viruses. *Bor. Gaz.*, 95: 419-436. 1934.
- (12) BLACK, L. M. A study of potato yellow dwarf in New York. *Cornell Univ. Agr. Exp. Sta. Mem.*, 209. 23 pp. 1937.
- (13) ——. Properties of the potato yellow-dwarf virus. *Phytopath.*, 28: 863-874. 1938.
- (14) BRIERLEY, P. Two distinct viruses from the mosaic complex in *Lilium longiflorum*. (Abst.) *Phytopath.*, 29: 3. 1939.
- (15) BUCHANAN, R. E., and C. MURRAY. Veterinary Bacteriology. Ed. 2. *Philadelphia and London* (W. B. Saunders Co.), 1916.

- (16) CALDWELL, J. On the interactions of two strains of a plant virus; experiments on induced immunity in plants. *Proc. Roy. Soc. London, B*, 117: 120-139. 1935.
- (17) CARNER, E. Attenuation of the virus of sugar beet curly-top. *Phytopath.*, 15: 745-757. 1925.
- (18) —, and C. F. LACKY. Further studies on attenuation of the virus of sugar beet curly-top. (Abst.) *Phytopath.*, 18: 951. 1928.
- (19) CHESTER, K. S. The problem of acquired physiological immunity in plants. *QUART. REV. BIOL.*, 8: 129-154, 275-324. 1933.
- (20) —. Specific quantitative neutralization of the viruses of tobacco mosaic, tobacco ring spot, and cucumber mosaic by immune sera. *Phytopath.*, 24: 1180-1202. 1934.
- (21) —. Serological evidence in plant-virus classification. *Phytopath.*, 25: 686-701. 1935.
- (22) —. Separation and analysis of virus strains by means of precipitin tests. *Phytopath.*, 26: 778-785. 1936.
- (23) —. Serological studies of plant viruses. *Phytopath.*, 27: 903-912. 1937.
- (24) COLE, R., and A. G. KUTTNER. A filterable virus present in the submaxillary glands of guinea pigs. *Jour. Exp. Med.*, 44: 855-874. 1926.
- (25) CONN, H. W., and H. J. CONN. Bacteriology. A Study of Microorganisms and Their Relation to Human Welfare. Ed. 3. *Baltimore* (Williams & Wilkins Co.), 1926.
- (26) DENNIS, R. W. G. Studies on *Solanum* virus 4. *Phytopath.*, 29: 168-177. 1939.
- (27) DOOLITTLE, S. P. *Commelina nudiflora*, a monocotyledonous host of celery mosaic. (Abst.) *Phytopath.*, 21: 114-115. 1931.
- (28) —, and F. L. WELLMAN. *Commelina nudiflora*, a monocotyledonous host of celery mosaic in Florida. *Phytopath.*, 24: 48-61. 1934.
- (29) DVORAK, M. The effect of mosaic on the globulin of potato. *Jour. Infect. Dis.*, 41: 215-221. 1927.
- (30) DYKSTRA, T. P. A study of the yellow mosaics of potato. (Abst.) *Phytopath.*, 29: 6. 1939.
- (31) —. A study of viruses infecting European and American varieties of potato, *Solanum tuberosum*. *Phytopath.*, 29: 40-67. 1939.
- (32) ELMER, O. H. Transmissibility and pathological effects of the mosaic disease. *Iowa Agr. Exp. Sta. Res. Bull.*, 82: 37-92. 1925.
- (33) FOSTER, A. C., and G. F. WEBER. Celery diseases in Florida. *Florida Agr. Exp. Sta. Bull.*, 173. 1924.
- (34) FROMME, F. D., and S. A. WINGARD. Black-fire or angular-leafspot of tobacco. *Va. Agr. Exp. Sta. Tech. Bull.*, 25. 43 pp. 1922.
- (35) —, and C. N. PRIODE. Ringspot of tobacco; an infectious disease of unknown cause. *Phytopath.*, 17: 321-328. 1927.
- (36) GOM, R. W., and G. L. PELTIER. Further studies on the effect of environment on potato degeneration diseases. *Nebr. Agr. Exp. Sta. Res. Bull.*, 29. 32 pp. 1925.
- (37) GRAINGER, J. The movement of tobacco mosaic virus in its host. *Ann. Appl. Biol.*, 20: 236-257. 1933.
- (38) HENDERSON, R. G., and S. A. WINGARD. Further studies on tobacco ring spot in Virginia. *Jour. Agr. Res.*, 43: 191-207. 1931.
- (39) HOGAN, I. A. Two viruses of the cucumber mosaic group on tobacco. *Ann. Appl. Biol.*, 22: 27-36. 1935.
- (40) HOLMES, F. O. Accuracy in quantitative work with tobacco mosaic virus. *Bot. Gaz.*, 86: 66-81. 1928.
- (41) —. Movement of mosaic virus from primary lesions in *Nicotiana tabacum* L. *Contr. Boyce Thompson Inst.*, 4: 297-322. 1932.
- (42) —. Symptoms of tobacco mosaic disease. *Contr. Boyce Thompson Inst.*, 4: 323-357. 1932.
- (43) —. A masked strain of tobacco-mosaic virus. *Phytopath.*, 24: 845-873. 1934.
- (44) —. Comparison of derivatives from distinctive strains of tobacco-mosaic virus. *Phytopath.*, 26: 896-904. 1936.
- (45) HUDSON, N. P., and C. B. PHILIP. Infectivity of blood during the course of experimental yellow fever. *Jour. Exp. Med.*, 50: 583-599. 1929.
- (46) JENSEN, J. H. Isolation of yellow-mosaic viruses from plants infected with tobacco mosaic. *Phytopath.*, 23: 964-974. 1933.
- (47) —. Studies on the origin of yellow-mosaic viruses. *Phytopath.*, 26: 266-277. 1936.
- (48) —. Studies on representative strains of tobacco-mosaic virus. *Phytopath.*, 27: 69-84. 1937.
- (49) JOHNSON, E. M., and W. D. VALLBAU. Susceptibility of tobacco plants visibly affected with mild tobacco mosaic to other strains of the virus. *Ky. Agr. Exp. Sta. Res. Bull.*, 360: 192-201. 1935.

- (50) JOHNSON, J. The relation of air temperature to certain plant diseases. *Phytopath.*, 11: 446-458. 1921.
- (51) —. The attenuation of plant viruses and the inactivating influence of oxygen. *Science*, 64: 210. 1926.
- (52) —. The classification of plant viruses. *Wisc. Agr. Exp. Sta. Res. Bull.*, 76. 15 pp. 1927.
- (53) —. Tobacco streak, a virus disease. *Phytopath.*, 26: 285-292. 1936.
- (54) —. An acquired partial immunity to the tobacco streak disease. *Trans. Wisc. Acad. Sci., Arts, and Let.*, 30: 27-34. 1937.
- (55) JORDAN, E. O. A Text-book of General Bacteriology. Philadelphia and London (W. B. Saunders Co.), 1908.
- (56) KOCK, G. v. D. W. DE. A contribution to the study of the virus, haematology, and pathology of infectious anemia of equines under South African conditions. *Union So. Afr. Dept. Agr. Rept.*, 9-10: 253-313. 1924.
- (57) KÖHLER, E. Untersuchungen über die Viruskrankheiten der Kartoffel. III. Weitere Versuche mit Viren aus der Mosaikgruppe. *Phytopath. Ztschr.*, 7: 1-30. 1934.
- (58) KUNKEL, L. O. Studies on acquired immunity with tobacco and aucuba mosaics. *Phytopath.*, 24: 437-466. 1934.
- (59) —. Possibilities in plant virus classification. *Bot. Rev.*, 1: 1-17. 1935.
- (60) —. Immunological studies on the three peach diseases, yellows, rosette, and little peach. *Phytopath.*, 26: 201-219. 1936.
- (61) —. Effect of heat on ability of *Cicadula seminata* (Fall.) to transmit aster yellows. *Am. Jour. Bot.*, 24: 316-327. 1937.
- (62) —. Isolation of mild strains of aster yellows from heat-treated leaf-hoppers. (Abst.) *Jour. Bact.*, 34: 132. 1937.
- (63) —. New views in virus disease research. Chapt. IV in: Science in Progress. (Sigma Xi Lectures, 1937-38), New Haven (Yale University Press), pp. 112-132, 301-303. 1939.
- (64) LACKAY, C. F. Attenuation of curly-top virus by resistant sugar beets which are symptomless carriers. *Phytopath.*, 19: 975-977. 1929.
- (65) —. Further studies of the modification of sugar beet curly-top virus by its various hosts (Abst.) *Phytopath.*, 19: 1141-1142. 1929.
- (66) LEMLEY, J. W., and J. M. WALLACE. Acquired tolerance to curly top in tomato. *Phytopath.*, 28: 548-553. 1938.
- (67) LIESENHUTZ, B. Geflügelpocke. In: Prowazek's "Handbuch der pathogenen Protozoen" (Barth), Leipzig. 1912.
- (68) MATSUMOTO, T. Antigenic properties of tobacco mosaic juice. *Jour. Soc. Trop. Agr. Japan*. 1: 291-300. 1930.
- (69) MCKINNEY, H. H. Virus mixtures that may not be detected in young tobacco plants. *Phytopath.*, 16: 893. 1926.
- (70) —. Mosaic diseases in the Canary Islands, West Africa, and Gibraltar. *Jour. Agr. Res.*, 39: 557-578. 1929.
- (71) —. Differentiation of viruses causing green and yellow mosaics of wheat. *Science*, 73: 650-651. 1931.
- (72) McWHORTER, F. P. The antithetic virus theory of tulip-breaking. *Ann. Appl. Biol.*, 25: 254-270. 1938.
- (73) NISHIMURA, M. A carrier of the mosaic disease. *Bull. Torrey Bot. Club*, 45: 219-233. 1918.
- (74) NORVAL, I. P. Derivatives from an unusual strain of tobacco-mosaic virus. *Phytopath.*, 28: 675-692. 1938.
- (75) OORTWIJN BORTJES, J. G. Verzwakking van het virus der topnecrose, en verworven immuniteit van aardappelrassen ten opzichte van dit virus. *Tidschr. Plantenz.*, 39: 249-262. 1933.
- (76) PRICE, W. C. Acquired immunity to ring-spot in Nicotiana. *Contr. Boyce Thompson Inst.*, 4: 359-403. 1932.
- (77) —. Isolation and study of some yellow strains of cucumber mosaic. *Phytopath.*, 24: 743-761. 1934.
- (78) —. Acquired immunity from cucumber mosaic in zinnia. *Phytopath.*, 25: 776-789. 1935.
- (79) —. Classification of southern celery-mosaic virus. *Phytopath.*, 25: 947-954. 1935.
- (80) —. Virus concentration in relation to acquired immunity from tobacco ring spot. *Phytopath.*, 26: 503-529. 1936.
- (81) —. Specificity of acquired immunity from tobacco-ring-spot diseases. *Phytopath.*, 26: 665-675. 1936.
- (82) —. Classification of lily-mosaic virus. *Phytopath.*, 27: 561-569. 1937.
- (83) —. Studies on the virus of tobacco necrosis. *Am. Jour. Bot.*, 25: 603-612. 1938.
- (84) RIVERS, T. M. Some general aspects of filterable viruses. In: Rivers, T. M. Filterable Viruses. Baltimore (The Williams & Wilkins Co.), 1928.

- (85) SALAMAN, R. N. Protective inoculation against a plant virus. *Nature*, 131: 468. 1933.
- (86) —. Immunity to virus diseases in plants. *Rept. 3rd Intern. Congr. Comp. Path.*, 1: 167-178. 1936.
- (87) —. Acquired immunity against the "Y" potato virus. *Nature*, 139: 924-925. 1937.
- (88) SANFELICE, F. Untersuchungen über das Epithelioma contagiosum der Tauben. *Ztschr. Hyg. u. Infektionskr.*, 76: 257-281. 1913.
- (89) SILBRACHMIDT, K. Studien zum Nachweis von Antikörpern in Pflanzen. II, Teil B. (Beiträge zur Frage der Resistenz und Immunität von Pflanzen gegenüber dem infizierenden Agens der Viruserkrankheiten.) *Beitr. Biol. Pfl.*, 20: 105-178. 1933.
- (90) SMITH, K. M. On the composite nature of certain potato virus diseases of the mosaic group as revealed by the use of plant indicators and selective methods of transmission. *Proc. Roy. Soc. London, B*, 109: 251-267. 1931.
- (91) —. The present status of plant virus research. *Biol. Rev.*, 8: 136-179. 1933.
- (92) —. Recent Advances in the Study of Plant Viruses. *London* (J. and A. Churchill), 1933.
- (93) —. Two strains of streak: a virus affecting the tomato plant. *Parasit.*, 27: 450-460. 1935.
- (94) —. A new virus disease of tomatoes. *Nature*, 135: 908. 1935.
- (95) —. A new virus disease of the tomato. *Ann. Appl. Biol.*, 22: 731-741. 1935.
- (96) —. A Textbook of Plant Virus Diseases. *Philadelphia* (P. Blakiston's Son and Co.), 1937.
- (97) —, and J. G. BALD. A description of a necrotic virus disease affecting tobacco and other plants. *Parasit.*, 27: 231-245. 1935.
- (98) STANLEY, W. M. The isolation and properties of tobacco mosaic and other virus proteins. *The Harvey Lectures, 1937-38*, 33: 170-204. 1938.
- (99) STEWART, F. C. Two destructive lily diseases. *N. Y. State Agr. Exp. Sta. Ann. Rept.*, 1895: 520-524. 1896.
- (100) STORRY, H. H. A new virus of maize transmitted by *Cicadulina* spp. *Ann. Appl. Biol.*, 24: 87-94. 1937.
- (101) TALLAFERRO, W. H. The Immunology of Parasitic Infections. *N. Y. (The Century Co.)*, 1929. (p. 265.)
- (102) TEN BROECK, C., E. W. HURST, and E. TRAUB. Epidemiology of equine encephalomyelitis in the eastern United States. *Jour. Exp. Med.*, 62: 677-685. 1935.
- (103) THOMAS, A. African horse-sickness (Pestis equorum). *Sci. Bull. Union So. Afr. Dept. Agr. Pretoria*, 19. 30 pp. 1921.
- (104) THUNO, T. H. Smetstof en plantencel bij enkele virusziekten van de tabakspiant. *Handel. Nederl. Ind. Natuurwetenschap. Congr.* 6^{de}, 1931: 450-463. 1931.
- (105) —. Infective principle and plant cell in some virus diseases of the tobacco plant. *Handel. Nederl. Ind. Natuurwetenschap. Congr.* 7^{de}, 1935: 496-507. 1936.
- (106) TOWLEY, W. W. C. An Outline of Immunity. *Baltimore* (William Wood and Co.), 1933.
- (107) TRAUB, E. Persistence of lymphocytic choriomeningitis virus in immune animals and its relation to immunity. *Jour. Exp. Med.*, 63: 847-861. 1936.
- (108) —. Factors influencing the persistence of choriomeningitis virus in the blood of mice after clinical recovery. *Jour. Exp. Med.*, 68: 229-250. 1938.
- (109) VALLEAU, W. D. Seed transmission and sterility studies of two strains of tobacco ring-spot. *Ky. Agr. Exp. Sta. Res. Bull.*, 327: 43-80. 1932.
- (110) —. Do tobacco plants recover and develop an immunity from ring spot? (*Abst.*) *Phytopath.*, 23: 37. 1935.
- (111) —. Do tobacco plants recover from and develop immunity to ring spot? *Ky. Agr. Exp. Sta. Bull.*, 360: 181-191. 1935.
- (112) WELLMAN, F. L. Identification of celery virus 1, the cause of southern celery mosaic. *Phytopath.*, 24: 695-725. 1934.
- (113) —. Infection of *Zea mays* and various other Gramineae by the celery virus in Florida. *Phytopath.*, 24: 1035-1037. 1934.
- (114) —. The host range of the southern celery-mosaic virus. *Phytopath.*, 25: 377-404. 1935.
- (115) WINGARD, S. A. Hosts and symptoms of ring spot, a virus disease of plants. *Jour. Agr. Res.*, 37: 127-153. 1928.
- (116) WOODS, A. F. The Bermuda lily disease: a preliminary report of investigations. *U. S. Dept. Agr., Div. Veg. Physiol. and Path., Bull.*, 14. 15 pp. 1897.
- (117) ZIMMER, H. On postulates of proof in problems of the bacterial life cycle. *Science*, 75: 256-258. 1932.
- (118) —, J. F. ENDERS, and L. D. FOTHERGILL. Immunity. Principles and Application in Medicine and Public Health. Ed. 5 of Resistance to Infectious Diseases. *N. Y. (The Macmillan Co.)*, 1939.



NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will frequently appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to Dr. Raymond Pearl, Editor of THE QUARTERLY REVIEW OF BIOLOGY, 1901 East Madison Street, Baltimore, Maryland, U. S. A.

BRIEF NOTICES

EVOLUTION

FOSSIL ORTHOPTERA ENSIFERA. Vol. 1, text; Vol. 2, plates.

By Frederick E. Zeuner. British Museum (Natural History), London. Vol. 1, 158. Vol. 2, £1. 8½ x 5½; Vol. 1, xiii + 321; Vol. 2, 80 plates; 1939.

It is indeed fortunate that the very fine collection of fossil Orthoptera in the Natural History department of the British Museum has had such an able interpreter as Zeuner.

The order Orthoptera (earwigs, cockroaches, stick insects, locusts, crickets) is not large in number of species but its distribution is world wide. Possibly no small factor in the ubiquity of these insects is that their ancestors got started a long time ago. Geologically the group is the oldest of the winged orders of insects.

"The Ensifera as a separate stock can be traced as far back as the Upper Carboniferous. Their ancestors belong to the Protorthoptera and are closely related to those of the Acridioides which form the other large suborder of the Orthoptera Saltatoria. This surprising phylogenetic independence of the Ensifera justifies their treatment in a separate Catalogue." Zeuner has been able "to reconstruct the evolution of all the families concerned and to find the probable causes of the divergence of the various stocks."

The textual part concludes with an extensive literature list and a useful index. The illustrations which form so important a part of the report are grouped together in a separate volume and consist of (a)

numerous line drawings largely showing wing venation and pattern and (b) photographic reproductions mostly of the fossil forms of Ensifera, many of which have been found embedded in amber.



STUDIES ON THE ICE AGE IN INDIA AND ASSOCIATED HUMAN CULTURES.

By H. de Terra and T. T. Patterson. Carnegie Institution of Washington, Washington, D. C. \$6.50 (paper); \$7.50 (cloth). 11½ x 9; xi + 354 + 56 plates; 1939.

This report includes studies on the Ice Age cycle in the Himalaya and the Pleistocene history of Stone Age Man in other parts of India. These studies were made from the geologic and archaeologic results of a 1935 expedition to India under the direction of H. de Terra in association with T. T. Patterson and P. T. de Chardin. The five areas in India with which this report is concerned are: (1) Kashmir, (2) Potwar-Indus (northwestern Punjab), (3) Narbada Valley near Hoshangabad and Narsinghpur, (4) Madras, and (5) Sukkur and Rohri, Upper Sind. In addition to a discussion of the Ice Age in southwestern Kashmir, four other subjects are presented, but in lesser detail: the Pleistocene geology and Stone Age cultures in northwest and peninsular India; the Pleistocene in the Narbada Valley of Central India; the stratigraphic and typologic sequence of the

Madras paleolithic industries; and the late Stone Age sites at Sukkur and Rohri on the lower Indus of Upper Sind. This detailed work is an excellent contribution to geologic and archaeologic studies on the Himalayan Ice Age and early Man in Southern Asia. There are numerous text figures and maps and photographic plates. Bibliography, index, and two folding maps are included.



TEXTBOOK OF PALEOBOTANY.

By William C. Darrab. D. Appleton-Century Co., New York and London. \$6.00.
8 $\frac{3}{4}$ x 6; xii + 441; 1939.

Although many studies have appeared within the last twenty years dealing with fossil plants, no suitable textbook for the beginner has been issued. The author of the present text gives a biological rather than a geological approach to the subject. He assumes on the reader's part a working knowledge of general botany, of the elements of plant anatomy and some knowledge of historical geology. The four main divisions of the book are as follows: I. General principles (4 chapters)—a discussion of geological and biological principles and the paleobotany of coal. II. The paleontological history of the vascular plants (12 chapters)—this begins with the Psilopsida and ends with sections on the origin and geological history of the angiosperms. III. The succession of ancient floras (4 chapters)—Paleozoic, Mesozoic, Cenozoic floras and the origin of existing floras. IV. General results (3 chapters)—fossil thallophytes and bryophytes, concepts of paleobotany and a reasonable phylogeny of vascular plants. Numerous illustrations appear throughout the text and each chapter is well documented. An excellent working index is provided.



GENESIS AND SCIENCE.

By Harold W. Clark. (Obtainable from the author, Angwin, Calif.). 15 cents.
7 x 5; 36; 1940 (paper).

"It is a tragic fact that the great men of the world have refused to see the beautiful

truths of creationism, and have turned their attention to the evolutionary interpretation of nature." Mr. Clark believes that inasmuch as the Bible is wholly and literally true, being God's word to man, it must be in perfect agreement with science, which studies God's works of nature. He attempts to reconcile the two by the lopsided compromise of contorting the findings of science to agree with the story of the creation. In two pages the writer breaks down the evidences of evolution from studies of comparative anatomy, embryology, blood tests, and vestigial structures. He claims that all of the rock strata could have been laid down in a very short period of time as a result of wave action during the flood. Not only intelligent biologists, but intelligent theologians as well will find these pages a lot of tommy-rot.



THOUGHTS ON EVOLUTION. IV. *Rejection by American Ethnologists. Anthropological Series of the Boston College Graduate School, Vol. 4, No. 4, Serial No. 16.*

By Joseph J. Williams, S.J. Boston College Press, Chestnut Hill, Mass. Subscription, \$3.00; Single copy, \$1.00.
9 $\frac{1}{2}$ x 6 $\frac{1}{2}$; 29; 1939 (paper).

This is a periodical containing two articles. One is a report on recent excavations at Ksar 'Akil, and the other an attempt to prove that American ethnologists have repudiated the theory of evolution. This latter essay is one of a series and perhaps it is not fair to pass judgment upon it apart from its predecessors. The author draws heavily on Boas, Goldenweiser, Lowe, Kroeber, and others to put *Homo sapiens* outside the pale of evolution, but about all he accomplishes is to show that authorities are not agreed as to whether the pleistocene sub-men were ancestors or only collateral relatives of modern man.



GENETICS

CONGENITAL MALFORMATIONS. *A Study of Parental Characteristics with Special Reference to the Reproductive Process.*

By Douglas P. Murphy. *University of Pennsylvania Press, Philadelphia.* \$1.50. 9 x 6; vi + 98; 1939 (paper).

This monograph reports the results of an investigation which had for its main stated purpose to determine whether a higher than expected number of congenitally malformed infants were born in families where such a birth had already occurred. In addition, the author has also examined other factors that might be related to the incidence of congenital malformations, viz.: socio-economic status and health of the parents, age, pregnancy, and puerperal history of the mothers. The material was obtained by selecting from the records of the deaths that took place from 1929 to 1934 in Philadelphia all those certificates stating that congenital malformation was the cause of death. These numbered 1476 but in only 890 instances (884 families) had the diagnosis been confirmed. The family inquiry was concerned with the latter group and all the information desired was obtained for 501 families. With regard to the main objective of the study the findings are interpreted to indicate that in families in which a malformed child has been born the chances of another malformed child being born are 25 times greater than for the general population. Moreover, it was apparently found that the older the mother the higher are the chances of a malformed offspring and the birth of this is usually preceded by a period of relative sterility. No association was discovered between the incidence of malformation and the social status, health, and puerperium of the mother, or the age of father and mother. The author is therefore led to conclude that "congenital malformations arise solely from influences which affect the germ cells prior to fertilization." This conclusion is acceptable and one to be expected on the basis of the findings of other students of the problem. It should be remarked that, as presented, the results of this investigation are not completely probative. The biometric analysis is weak and the author is apparently entirely oblivious of the fallacies that could arise from the sampling technique employed.

STUDIES ON THE PHYSIOLOGY, GENETICS, AND EVOLUTION OF SOME CLADOCERA. *Carnegie Institution of Washington, Publication No. 513. Paper No. 39, Department of Genetics.*

By A. M. Banta, with the collaboration of Thelma R. Wood, L. A. Brown, and Lester Ingle. *Carnegie Institution of Washington, Washington, D. C.* \$2.50 (paper); \$3.00 (cloth). 11½ x 9; x + 255 + 4 folding charts; 1939.

These studies, begun in 1911 and continued to the present, were started during that period when selection was looked upon as the prime mover of evolution. *Cladocera* proved to be an organism well adapted to experiments in such fields. Banta, by using selection, established two races—the first reacting very rapidly to light, the second reacting slowly or not at all.

Closer studies upon this form led to the finding of sex intergrades which proved to be mutational. The effect of environmental conditions upon the sex ratio of the offspring also received much attention. It was found that increasing temperature gave a bimodal curve for male percentages and that these centered at 14°C. and 20°C. Density of population was found to be an important factor in the determination of sex. An isolated mother produced only females. When the maternal density was 8 per culture, 56 per cent of the offspring were males. The evolutionary significance of the findings is discussed.

A bibliography of 202 titles is present. Drawings and diagrams aid in the clarification of the text and a fine index is appended.



BLOOD GROUPS IN AFRICA. *Publication of the South African Institute for Medical Research No. XLIV. (Vol. IX).*

By Ronald Elsdon-Dew. *South African Institute for Medical Research, Johannesburg.* Free. 10½ x 7½; 66; 1939 (paper). This paper is the sixth in a series, published by the South African Institute for Medical Research, and is a continuation of an investigation of the blood groups of the tribes of Africa—the object of the

investigation being to trace the racial history of these peoples (if possible) and place them in their proper order of origin. The present study deals with tribes in East Africa, and tables and charts present a clear reading of their blood grouping and the several gene frequencies. There is also a recapitulation of results previously published, and while no theories of ethnological distribution have been proven, very considerable knowledge has been added to that already gained. This investigation together with those of earlier date should be of special interest to geneticists.



HEREDITY AND SOCIAL PROBLEMS.

By L. L. Burlingame. McGraw-Hill Book Co., New York and London. \$3.50. 9 x 6; xi + 369; 1940.

This textbook aims to give students of biology a general view of the significance of the findings of modern genetics in relation to social problems. The first third of the book contains a fairly simple exposition of genetics and its application to the study of the inheritance of physical characters in man. The remaining part, about two-thirds of the book, is concerned with an examination of the evidence on the inheritance of behavioristic and mental traits: criminality, intelligence, mental deficiency, etc. Sandwiched among these is a discussion of population problems and of race. The author has obviously been influenced by the recent pronouncements of the eugenicists and it is apparently from such a standpoint that he presents the subject.



PEDIGREES AND CHECKERBOARDS.

By E. Fletcher Barrows. Edwards Bros., Ann Arbor, Mich. \$1.50. 10½ x 8½; 233; 1940 (paper).

Cases in great variety are presented for exercise in the determination (a) from given pedigrees, of the probable genetic make-up of the individuals concerned, and (b) from crosses in which the parental genotypes are specified, of what kinds of

offspring and what Mendelian ratios may be expected. The construction of numerous Punnett squares is suggested. All fundamental aspects of modern genetic theory are covered, but no breeding experiments are outlined. This is a manual for desk work only.



THE PRINCIPLES OF HEREDITY. *Second Edition.*

By Laurence H. Snyder. D. C. Heath and Company, Boston and London. \$3.50. 8½ x 5½; xv + 452; 1940.

The present edition of this excellent text follows closely the organization of the early edition (reviewed Q.R.B., Vol., 10, p. 454) with but few minor changes. A new chapter on giant chromosomes has been added, synthesizing the investigations in this important branch of present day genetics. New illustrations have been added, and the lists of references extended.



GENERAL BIOLOGY

VITALISM: *Its History and Validity.*

By L. Richmond Wheeler. H. F. and G. Witherby, London. 15s. net. 8½ x 5½; xii + 275; 1939.

A great amount of painstaking scholarly research has gone into the making of this book, and the result will astonish those who have given only casual thought to the subject. Unfortunately, the title is somewhat misleading as the greater part of the book is taken up with interpretations of the thoughts of past authorities on vitalism, rather than with a consideration of vitalism itself as a living theory. But the book is better than its title.

The average man, if he thinks of vitalism at all, is likely to consider it an essentially modern development—the natural reaction to the materialism of the nineteenth century. But if he reads this book he will learn that not only was Aristotle the originator of the theory, but that the belief was held by practically all subsequent men of science (there were

of course not many of them) down to about the middle of the seventeenth century.

In this century a great many changes took place in the scientific thought of western Europe. The birth of the classical physics of Galileo and Newton naturally gave a mechanical slant to the speculations of natural philosophers. It also helped to drive into permanent oblivion the old belief that the baser metals could be transmuted into gold, by establishing the fixity of the elements. Under a materialistic philosophy this idea of fixity was easily transferred from the inorganic to the organic world, and the doctrine of the fixity of species was the result. Sporadic attempts to overthrow this doctrine were made at odd intervals by Erasmus Darwin, Lamarck, Robert Chambers and others, but it was never seriously challenged until the publication of the *Origin* by Charles Darwin in 1859.

To list the authorities whose contributions to the philosophy of vitalism are expounded by Wheeler from Aristotle and Galen to Jeans and Eddington would be to compile an encyclopedia of biography. Certainly not many have been missed. Yet the present reviewer puts down the book in a somewhat confused state of mind. This is partly due to inadequate documentation. There are practically no footnotes. Editorial comments are inserted parenthetically, thus interrupting the continuity and so adding to the difficulty of reading. The bibliographies at the end of each chapter make no pretense to completeness—if every citation in the text were listed the bibliographies would be several times their present length, and the usefulness of the book would be enhanced proportionately.

Another source of confusion is the use of technical terms to mean different things at different times. For instance the term "orthogenesis" is sometimes used to mean development past the optimum point for usefulness to that of danger—and at other times to mean teleogenesis. Also, the word "mechanism" is used as if synonymous now with machine, now with automaton. But this is not so much the author's fault as of those he quotes.

But despite this confusion there is much

in the book to be commended. The index is quite exhaustive and there is great clarity of expression throughout the work. Perhaps the reviewer may be pardoned for closing with a quotation from the work that he finds enlightening:

Vitalism and mechanism are the only two types of theoretical biology yet devised and both involve the analogy of a humanly constructed machine. Vitalism allows for a mechanic. Mechanism forgets that a mechanic is essential and only achieves being materialistic by omitting the 'psychological origin' of the machine.



DER KAMPF UMS DASEIN. *Eine biologisch-mathematische Darstellung der Lebensgemeinschaften und biologischen Gleichgewichte. Abhandlungen zur exakten Biologie, Heft 1.*

By Umberto D'Ancona. Translated by Ludwig Holzer. Verlag von Gebrüder Borntraeger, Berlin. RM. 15. 10 x 6½; x + 196 (paper).

The first portion of this work treats of the main contributions by men who have added to our knowledge of the behavior of biological populations. The equations of Lotka regarding interspecific relationships are dealt with. The fundamental concepts of the theory of Volterra concerning biological populations are extensively presented. The Verhulst-Pearl logistic curve is given and some of the experimental work of Pearl upon *Drosophila* is described. Other authors whose observations are noted include: Darwin, Möbius, Celli, Friederichs, Elton, and Gause.

The second portion of the work is concerned with principles of biological populations which may be drawn from the works of the foregoing scientists. At first glance the mathematics used and the conclusions drawn therefrom, may appear rather heavy for the biologist. The writer of the work, however, states: "Es [the book] handelt sich hier also nicht um eine mathematische Arbeit für Mathematiker, sondern um eine biologische für Biologen, in welcher die Mathematik als gedankliches Hilfsmittel dient."

The volume contains many graphs which amplify and clarify the text. An extensive bibliography is presented.

CARNEGIE INSTITUTION OF WASHINGTON.
Year Book No. 38, July 1, 1938-June 30, 1939.

Carnegie Institution of Washington, Washington, D. C. \$1.00 (paper); \$1.50 bound. 10 x 6½; xxxii + 394; 1939 (paper).

The first part of this report is concerned with official matters such as lists of officers and trustees, staff investigators, research associates connected with other institutions, etc. The President, Mr. Vannevar Bush, gives a general report on the present status of research work in the various branches of the Institution and outlines some of the problems that are either in the process of being investigated or are to be taken up in the future. There follow separate and more detailed departmental reports under the following headings: astronomy, terrestrial science, biological sciences, and historical research. To those who are familiar with the publications from the biological sections—both plant and animal—these reports are of especial interest as the reader obtains an understanding of the general scope of the work that is in progress. Also of interest to the biologist are those sections dealing with historical research where the first decade's accomplishments are reviewed, including the very fine work in the Maya field, the reports dealing with genetics, nutrition, and paleontology, early man, and historical geology.



ORGANISMEN UND UMWELT. 20 Vorträge.
Zweite Wissenschaftliche Woche zu Frankfurt A.M. 28.-30. Juni, 1939.

Edited by R. Otto in collaboration with K. Felix and F. Linke. Verlag von Theodor Steinkopff, Dresden and Leipzig. RM.

11.25. 9¼ x 6½; xiv + 275; 1939 (paper).

The principal theme of the papers presented was the relationship between the organism and its environment. Both plant and animal research were used as a basis for the discussions. Some of the subjects treated were: environment and heredity; race and environment; the importance of photodynamic phenomenon in biology; plants and radiation; influence of the radioactive environment upon the organism; the importance of frail elements

in the development and association of plants; specific immunity against micro-organisms. Each talk was followed by a general discussion which is placed at the end of each report.

There are many illustrations and a good index.



THE SEASONS AND THE FARMER. *A Book for Children.*

By F. Fraser Darling. Drawings by C. F. Tunnicliffe. The Macmillan Co., New York; The University Press, Cambridge.

\$2.25. 8½ x 6½; vii + 72; 1939.

The belief that many city children never get to see or know much about the farm has prompted Darling to write this somewhat romantic account of the farmer, his crops, his animals, and his work the year around. The subject matter and illustrations are drawn exclusively from British sources, and in consequence, the book will be of reduced value for American consumption. The author's consistent use of the words wheat and corn interchangeably when obviously referring to wheat would be extremely confusing to an American child. Many of the homely methods of English farming would be amusing to our machine-minded American farm children. However, for English consumption, the little volume will undoubtedly serve its purpose well.



THE WORLD UNDER THE SEA. *A Concise Account of the Marine World.*

By B. Webster Smith. D. Appleton-Century Company, New York and London.

\$3.00. 9 x 6; 230; 1940.

Because simpler studies of oceanography in the language of the layman are rare, the author has written this small book to fill the gap by setting before the reader "a plain and straightforward account of oceanic phenomena, followed by a brief and general survey of marine life." The volume includes chapters on submarine earthquakes and volcanoes, oceanic currents and tides, and a description of the ocean floor as well as accounts of many forms of marine life from sharks and rays

to marine plants and minute animals. It is well illustrated with photographs and drawings and there is an adequate index.



BIOLOGICAL DRAWINGS with Notes. Parts 1 and 2.

By Maud Jepson. Preface by H. Graham Cannon. Chemical Publishing Co., New York; John Murray, London. \$2.00. 11 $\frac{1}{2}$ x 9 $\frac{1}{2}$; Part 1, iv + 60; Part 2, iv + 60; 1939.

This splendid collection of biological drawings can be used to practical advantage by students in courses where the time is limited. They should be of great value to the student in the laboratory, furnishing, as they do, clear-cut concepts of botanical and zoological structures. The author has included numerous notes in addition to those used for labelling purposes. Parts I and II are bound together but have separate indices.



HUMAN BIOLOGY

CAPITALISM THE CREATOR. *The Economic Foundations of Modern Industrial Society.*

By Carl Snyder. The Macmillan Co., New York. \$3.75. 9 $\frac{1}{2}$ x 6 $\frac{1}{2}$; xii + 473; 1940.

During the last century mystics and humanitarians in general have greatly intensified their attacks against the capitalistic system, and in the last two decades, particularly the foundations of free trade have been badly shaken, if not destroyed. Today, in fact, it is a rather risky business to defend the system advocated and taught by Adam Smith. Therefore the author is to be greatly admired for his courage in making this panegyric of capitalism. The theme that Snyder develops and embroiders is that capitalism is an integral aspect of our ways of living and that because of it this country especially has advanced to a high social level. Without capitalism, without the right of private property and profit the great industrial progress of this country would never have been achieved. The author goes to great lengths, employing a

mass of facts and figures, to demonstrate the truth of this view. The evidence in its favor is formidable and none but fools or knaves could deny it. However, is it with respect to this point that many argue for a modification or the overthrow of capitalism? As Pareto, on whom the author leans heavily, pointed out the problems of applied economics involve a strong non-rational element—that of so-called humanitarianism—and it is on these grounds that communists, socialists, and new-dealers have made what appears to be successful headway against the principles of liberal economy. This book has apparently been written for the layman and it is one of the clearest and most complete expositions of capitalistic principles that has appeared in many years, besides containing an adequate interpretation and summary of the economic history of this country.



HOW CAME CIVILIZATION?

By Lord Raglan. Methuen and Co., London. 6s. net. 7 $\frac{1}{2}$ x 5; xi + 191; 1939.

The author's belief is that the human race does not possess an instinct or natural tendency towards progress but that civilization is a rare manifestation of the sporadic creative efforts of a few of its "citizens." In line with this belief the author reasons that the so-called "primitive" devices which scientists believed primitive peoples to have developed were invented once and once only and in one place, and from that place were diffused to other areas. The author believes that the theory of multiple inventions is a fallacious one.

... that progress has always been rare and sporadic; and that today there is, outside Western civilization, nothing but stagnation or decay.

So far as we know, no savage has ever invented anything, and the researches of experts lead them to the conclusion that all the elements of civilization, including agriculture and the domestication of animals, the use of metals, bows, boats, pots and wheels, were developed once only, each at some one spot, and thence diffused to where they are now found.

The author shows that the invention of the bow and arrow was not a simple

invention but a complicated one involving at the least, nine steps in the making. This complexity gives one reason "for doubting whether it was invented independently by primitive savages in various parts of the world." *How Came Civilization* presents a strong if not wholly convincing argument in favor of the diffusionist school of thought. Bibliography, index and illustrations are included.



ALL TOO HUMAN. *An Unconventional Autobiography.*

By Owen Berkeley-Hill. Peter Davies, London. 8s. 6d. net. $7\frac{3}{4} \times 5\frac{3}{4}$; [8] + 384; 1939.

General speaking all autobiographies are interesting and this volume is certainly no exception to that rule. The author is an eminent psychiatrist who stems from the distinguished English family that included among its members Sir Rowland Hill, the originator of Penny Postage in England and of modern postal systems generally.

Berkeley-Hill was educated at Oxford, Göttingen, Nancy, and London. Soon after the turn of the century he entered the Indian Medical Service. In due time he married a Hindu wife of the Tiyyan caste. This proved in the event to be an enduring and happy marriage, in spite of the social difficulties it entailed for the partners to it and their children.

One of the things that makes this an extraordinary autobiography is the author's frankness about his own sex life, to which one whole chapter is devoted to say nothing of frequent references to the same subject through the book. The following lines constitute the only preface the book has: "This book has been written at the express desire of my children. What they will think of it and of me if they ever read it I cannot even guess. However, I have done my best to write the story of my life, most of which, as Sydney Smith said of his own, has been 'like a razor, either in hot water or a scrape'."

It seems reasonably safe to say that no

other father ever told his children, through the medium of a published book, quite so much about his sex experiences and attitudes.

Altogether a remarkable book thoroughly indexed.



THE RACES OF CENTRAL EUROPE. *A Footnote to History.*

By G. M. Morant. Preface by J. B. S. Haldane. George Allen and Unwin, London. 5s. net. $7\frac{1}{2} \times 4\frac{1}{2}$; 163; 1939.

The purpose of the study reported in this book is "to discover how far the physical evidence relating to the peoples of Central Europe leads to conclusions regarding 'race' that are in accordance with those derived from cultural data and primarily from language." In particular, the author wishes to bring to the attention of the general public the fallacies of the concept of race as preached by certain German writers. He therefore examines some of the available data on stature, the cephalic index, skin, hair and eye color, hair form, and blood groups of samples of German, Czechoslovakian, Austrian, Polish, and Hungarian populations. As is well known, for some physical traits these national groups do differ in terms of the average measure. But due to the variability within each group, not all the individuals of one group are distinguished relative to these traits from all the persons of the other groups. Moreover, the author emphasizes that in passing from one country to another geographically contiguous the change in the measure of the physical characteristics is gradual and not abrupt as is the change in language and culture. This point is questionable since it needs proof that there is a sudden transition in the language actually spoken by the inhabitants on the two sides of a boundary line. The author closes with a plea for a greater popular diffusion of anthropological knowledge so that ideas such as those of racial purity and superiority will not be easily accepted by the general public. Every human biologist will certainly associate himself with this plea.

INDIANS OF THE UNITED STATES. *Four Centuries of Their History and Culture.*

By Clark Wissler. Doubleday, Doran and Co., New York. \$3.75. 9½ x 6½; xvi + 319 + 18 plates; 1940.

This is the first of a special series of science books prepared for the general public under the auspices of the American Museum of Natural History. In this volume Wissler describes the Indians who inhabited North America in 1492 and when possible traces their movement to the present day. The book is divided into three parts and in the first, by way of introduction, the author summarizes the evidence that has been uncovered about prehistoric Indians and the deductions and conclusions to which such findings have led. The substance of the book is contained in the second part. For each of the major ethnic groups into which the North American Indians can be segregated a detailed account is given of the physical characteristics, political organization, mores, culture, geographic distributions and the history, particularly in relation to the wars with other Indians and with the white man. These accounts are made more interesting by the inclusion of short biographical sketches of the leading historical personalities of each group. In the third part the author discusses the consequences of the contacts between the white man and the Indian (mostly bad for the latter) and the future of the Indian in this country. For the purpose for which it has been prepared the book is excellent. The author has succeeded in giving a clear portrayal of the Indian and one that is about as accurate as could be possible without recourse to pedantry.



THE BAIGA.

By Verrier Elwin. With a Foreword by J. H. Hutton. John Murray, London. 30s. net. 8½ x 6; xxxi + 550 + 54 plates; 1939.

The Baiga were aborigines of Central India and are now found mainly in the Eastern Satpura Mountains. They number about 40,000 souls and apparently have not yet been much influenced either by the Hindu or the Western civilization. The author

has lived among them for almost a decade, having established schools, a dispensary, and a leper home in their country. In this report of his observations he describes fully their mode of living, customs and beliefs. The Baiga are not far above the hunting cultural level. Their daily life appears to be centered around the simple satisfaction of the physiological urges. The importance given to sexual manifestations is noteworthy and the author discusses their sex behavior at length and with what seems to be a more profound insight than most anthropologists possess. In addition to chapters on the social organization, jurisprudence, mythology, magic, healing art and folklore of the Baiga this book contains a very interesting one on the kinds of dreams reported by some of them. Particularly illuminating are the life-stories of some of the notable persons of the tribe. This book, so rich in authentic information, will be a source of reference for studies on numerous aspects of social behavior.



ECUADOR THE UNKNOWN. *Two and a Half Years' Travels in the Republic of Ecuador and Galápagos Islands.*

By Victor Wolfgang Von Hagen. Oxford University Press, New York. \$3.50. 8½ x 5½; 296 + 31 plates; 1940.

To recommend this thoroughly satisfying "travel" book is indeed a pleasure. It is a record of adventurous traveling combined with scientific observation of areas which have previously been visited but seldom described so well. The author, an entomologist, and his wife, a botanist, traveled in the high Andes, and on the sea and river levels of Ecuador to the picturesque cities and the upper Amazon territory. They journeyed as collectors for museums, as scientific observers, and as photographers—so the book is full of vital information. The experience of going to the native habitat of the South American condor, of lassoing two of the great birds and sending them back to the zoo in Memphis is enough to compensate the authors for all hardships endured.

But the main purpose of the expedition was to visit the Galápagos to make criti-

cal observations of changes that had occurred since Darwin's historic voyage one century earlier in 1835. A comparison of data of the two periods is presented with an account of the erection, on these islands, by the author and his wife, of a statue of the evolutionist. The book is well illustrated with photographs by the author. There is an index of eight pages.



A DOCTOR WITHOUT A COUNTRY.

By Thomas A. Lambie. *With an Introduction by Howard A. Kelly.* Fleming H. Revell Co., New York, London and Edinburgh. \$2.00. 8 x 5½; 252; 1939.

After many hardships, the missionary doctor accompanied by his wife and small children succeeded in crossing the Anglo Sudan into Abyssinia, where Addis Ababa eventually became the center of his activities. If one discounts the religious fervor that pervades the entire work there still remains a large fund of highly interesting information about the customs and beliefs of the natives, and about the animal life and vegetation of the country. Only Ethiopian citizens could hold title to missionary property in Ethiopia, so in 1934, at the personal request of Hailie Selassie, Dr. Lambie renounced his allegiance to the United States in order to become an Ethiopian citizen. Shortly after came the Italian invasion, with the consequent expulsion of his mission from Ethiopia. However, Dr. Lambie regards seeming defeat as a stepping stone to a greater and an ultimate triumph in that the tragedy of Ethiopia may lead to the spread of the Gospel in the Egyptian Sudan, where he now plans to return.



CHEROKEE CAVALIERS. *Forty Years of Cherokee History as Told in the Correspondence of the Ridge-Watie-Boudinot Family.*

By Edward E. Dale and Gaston Litton. University of Oklahoma Press, Norman.

\$3.00. 9 x 5½; xxiii + 319 + 7 plates + 1 folding chart; 1939.

An important story well told, without prejudice, this book deals with the successive evictions of the Cherokees from

their expulsion from their original home in Georgia to their final settlement in Oklahoma. It is not a story in which white Americans can take pride. The leaders of the Cherokee nation had intermarried with the whites to a great extent and their families were divided by the evictions. The story is told in 199 different letters published for the first time, written between 1832 and 1872 by various members of the related Ridge, Watie, and Boudinot families to each other.

The Cherokees were the most intellectual and the most highly cultured of all the aboriginal inhabitants of the United States. They were the only ones to develop a phonetic alphabet. They were the first to publish their own news magazines. The letters selected for publication here came from a collection of several thousand discovered in an Oklahoma farmhouse several years ago. From them we get the Indians' side of the story. The work is a scholarly presentation, thoroughly indexed and documented.



FRONTIER DOCTOR.

By Urling C. Coe. The Macmillan Co., New York. \$2.50. 8 x 5½; ix + 264; 1939.

The perseverance required by the "Doc" to meet hardship and to cope with ignorance and superstition among the settlers of our last frontier is realistically portrayed by Dr. Coe in this interesting little novel. The story is essentially an autobiography of the author for the years 1905 to 1911, and represents the diary he intended to keep (but never had time to) when he went to the little town of Bend, Oregon, to begin his medical career.

Still quite green from medical school, Dr. Coe soon found himself amputating limbs with a meat saw, reducing fractures by many ingenious methods, pulling teeth with pliers, and delivering babies by the dozens everywhere. Although the author sticks pretty close to the story he has to tell, he digresses now and then to take a few mild pokes at socialized medicine, and insists that individualism is the foundation of medicine, as well as all other institutions in our Democracy. For enter-

taining reading, we heartily recommend *Frontier Doctor*.



SIR JOHN FRANKLIN'S LAST ARCTIC EXPEDITION. *A Chapter in the History of the Royal Navy.*

By Richard J. Cyriax. Methuen and Co., London. 12s. 6d. net. 8½ x 5½; xviii + 222 + 3 folding maps; 1939.

Here is a scholarly presentation of completely authenticated data regarding early British exploration in the Arctic. Expeditions previous to Sir John Franklin's last voyage are briefly outlined in order to give the historical background of this British search for the Northwest Passage. The detailed account includes a description of the painstaking preparation, and of the final sailing of H. M. ships, *Erebus* and *Terror*, in May 1845, under the command of Sir John Franklin. These vessels were the first to go into the Arctic equipped with steam engines, auxiliary to the sails, and in every possible way the latest devices and methods were used to insure the success of the voyage of discovery. But the outcome, as is well known, was a great national tragedy.

The full documentation of the text adds greatly to the interest of the reader, especially as many of these notes are given to the public for the first time. There are maps, appendices and brief biographies of the junior officers of the *Erebus* and *Terror*, as well as a six and a half page index.



ANTHROPOMETRIC OBSERVATIONS ON THE ESKIMOS AND INDIANS OF LABRADOR. *Anthropological Series, Field Museum of Natural History, Volume 31, Number 1. Publication 462.*

By T. Dale Stewart. *Material and Data Collected by William Duncan Strong. Field Museum of Natural History, Chicago.* \$1.75. 9½ x 6½; 163 + 16 plates; 1939 (paper).

The early pages of this publication are devoted to a discussion of the difficulties encountered in the study of Eskimo popu-

lations, particularly the problems of racial admixture and physical changes due to altered diet. Following this is a review of the theories of Eskimo and northern Indian migrations and the origin of the various cultures. The anthropometric data presented have a three-fold division—measurements on prehistoric and recent skeletons, on living Eskimos, and on living Indians—the last mentioned material being so meager as to have but little value. Mean values are given in sixty-four tables, while individual measurements are presented in the several appendices. The figures show that in prehistoric times the Labrador and Greenland Eskimos bore the closest skeletal resemblances, being considerably shorter than those of the Thule culture. Brief accounts are given as to population changes during the past century, longevity, and racial intermixture.



FURS TO FURROWS. *An Epic of Rugged Individualism.*

By Sydney Greenbie. The Caxton Printers, Caldwell, Idaho. \$3.50. 9 x 6; 413 + 30 plates; 1939.

This book tells the story of the important years in American pioneering history and the men who made it—the fur trappers—who, according to the author, were always some 500 miles ahead of the army and missionaries. Its interest is primarily centered in the thirty to forty years following the Louisiana Purchase and the acquisition of the territory west of the Mississippi. The author writes with interest and understanding of such notables as John Colter, John Jacob Astor, Manuel Lisa, the great American character Kit Carson, and other early Americans. Several chapters are devoted to the Navajo and Pueblo Indians and their customs and crafts. Dr. Carl P. Russell furnishes in the appendix a chronological outline of the history of American fur trade from 1497 to the present. A long and complete bibliography and index are included and the volume is well illustrated with photographs of Indians and reproductions of historical paintings.

NEW GUINEA EXPEDITION. *Fly River Area, 1936-1937.*

By Richard Archbold and A. L. Rand. Photographs by the Authors and L. J. Brass, G. H. H. Tate, M. J. Healy and L. A. Willis. Robert M. McBride and Co., New York. \$3.50. 10 x 7½; xviii + 206 + 1 folding map; 1940.

The second expedition of the authors into the little known Fly River region of New Guinea justly warrants the praise given it in the Foreword by Roy Chapman Andrews. If nothing more had come from the expedition than the trip, it would have been entirely successful in that it revolutionized the method of exploration into jungle country. The method was simply that of using an airplane to drop parachute loads of supplies at the various camp sites along the route of exploration, thus avoiding the necessity of using countless natives to pack the supplies through the dense jungle regions. The text is well written in a clear and interesting style, and is supplied with an index and an abundance of photographs and maps.



DOCTOR'S OFFICE.

By Vincent Tothill. With a Foreword by Owen Rutter. Blackie and Son, London and Glasgow. 7s. 6d. net. 7½ x 5½; vi + 288 + 8 plates; 1939.

Of the deluge of books by and about doctors which have almost drowned the literary horizon of late, the present volume is perhaps noteworthy only because of its locale—the island of Trinidad. From the windows of the doctor's office and through the eyes of the doctor himself, we get a glimpse of various and sundry aspects of life in this British New World possession. Dr. Tothill gives us his impressions of the natives of the island and how they live, Trinidad society, missions and their methods, education in Trinidad, the medical service, and something about Trinidad's possible future. The author is entirely devoid of any color complex and his years of experience, both as medical officer to a large sugar estate and as a private practitioner, have given him valuable inside information as to conditions on the island.

Dr. Tothill's frankness and straightforwardness add a pith and pungency to the book which may leave a bad taste in the mouths of some of his readers.



CHARITY AND THE STRUGGLE FOR EXISTENCE. *The Huxley Memorial Lecture for 1939. Reprinted from The Journal of the Royal Anthropological Institute, Vol. LXIX, Part II, 1939.*

By R. R. Marett. Royal Anthropological Institute, London. 2s. net. 11 x 8½; 13; 1939 (paper).

This rather rambling and poorly organized lecture about a problem of compelling and perennial interest to philosophically minded students of human evolution finds its end point in the following words:

I therefore conclude, without exceeding my anthropological range, that in general our ethical policy has been sound all along, though here and there we have had to drop various habits by the way. But Charity, as I have contended throughout, can never grow obsolete. It is part of the permanent endowment of the race, seeing that Charity and Justice are as the heart and the head—with, perhaps, Holiness as the soul—of the whole evolutionary movement to which our nature is subject.

Marett contends that charity has its evolutionary origin in mother-love. Justice is thought to be the contribution of the father to the moral life of mankind, and to find its "ultimate affinities with male violence and the lust for power as typically displayed in sex-rivalry."

Altogether we cannot regard this as a particularly important contribution.



TWO MEN IN THE ANTARCTIC. *An Expedition to Graham Land 1920-1922.*

By Thomas W. Bagshawe. With a Foreword by Frank Debenham. The Macmillan Co., New York; The University Press, Cambridge. \$3.75. 8½ x 5½; xxi + 292 + 19 plates + 1 folding chart; 1939.

Living in a shack made of packing boxes and an old boat hull, two young men spent a year on the coast of Graham Land. This is the story of the hardships encountered during their isolation. However, the adventure was not without its compensa-

tions and the pleasures and trials alike are related in a manner which is entertaining and often quite amusing. The final quarter of the book is devoted to detailed meteorological and tidal observations, and to descriptions of the activities of whales, seals, and various birds. The men were transported to and from their base by whaling vessels, and the account of the whaling industry is of particular interest. The volume is well illustrated and indexed.



NEW ENGLAND COMMUNITY STATISTICAL ABSTRACTS. *Social and Economic Data for 175 New England Cities and Towns. Prepared for the Industrial Development Committee of the New England Council.*

Compiled by Ralph G. Wells and John S. Perkins. Bureau of Business Research, Boston University College of Business Administration, Boston. \$3.50. 11 x 8½; 15 + [350]; 1939 (paper).

This book is a collection of statistical data from 175 New England cities and towns. The information contained is primarily for the benefit of manufacturers and business men who may seek new locations and extensions of their operations, and are thus enabled to compare the relative advantages of the different communities of New England for their purposes. These statistics also contain much information useful in further studies on population and economics. The data compiled cover population (native and foreign born), municipal finances (tax rates, bond indebtedness, total property values, etc.), distribution of employment, vital statistics, housing data, educational facilities and other information, grouped so compactly that desired tables may be easily found. The statistics appear to be sound and reliable.



POPULATION. *A Problem for Democracy. The Godkin Lectures, 1938.*

By Gunnar Myrdal. Harvard University Press, Cambridge; Oxford University Press, London. \$2.00. 7½ x 5½; xiii + 237; 1940.

The Swedish investigator who is the author of this book believes that the population problem is the crucial problem of democracy. He points out that America has the unique strategic advantage—if only it can be capitalized—that this problem will mature to acuteness a couple of decades later than in some of the older democracies of northern and western Europe, among them his own. In a general and non-technical way he discusses political attitudes in the population problem, and the economic effects of population trends in western democratic industrial society, using Sweden as his point of reference.



MIGRATION AND SOCIAL WELFARE. *An Approach to the Problem of the Non-Settled Person in the Community.*

By Philip E. Ryan. Russell Sage Foundation, New York. 50 cents. 9 x 6; vi + 114; 1940 (paper).

An interesting study of the migratory population of the United States. It tells us about the different groups of people who move from one part of the country to another, and gives their reasons for so doing. It also gives a fund of information about the social and financial problems that states and communities have to deal with in the effort to care reasonably for this large body of transients. Mr. Ryan seems to think the nearest approach to a satisfactory control of the conditions of life surrounding the non-resident population would be through concerted action of all state and local agencies with government leadership.



POPULATION CHANGES IN THE RIO GRANDE GLAZE-PAINT AREA. *Archaeological Survey. Technical Series, Bulletin No. 9.*

By H. P. Mera. Laboratory of Anthropology, Santa Fe, New Mexico. \$2.00. 10½ x 8½; 41 + 23 maps; 1940 (paper).

In central New Mexico, in the river valley both north and south of Albuquerque, lived populations characterized by common types of pottery production. The movements and shifts of these populations

from the middle of the 14th century to the beginning of the 18th have been the subject of the author's study for nearly ten years. The distribution of certain archeological objects generally accepted as indicators of the presence or absence of these people has been taken as evidence of changes in their centers of population. Warfare seems to have been the ultimate incentive to movement in every case.



REFUGE IN THE ANDES.

By Rudolph Messel. *John Lane the Bodley Head, London.* 10s. 6d. net. $8\frac{1}{2} \times 5\frac{1}{2}$; 285 + 16 plates; 1939.

A group of German refugees had been settled in Colombia, South America, and apparently something had gone wrong with the Colony. This is the story of the author's journey from London to that settlement in an effort to clear up the difficulty. In many ways the book reads like a novel, having a genuine villain who is the personification of the "clutching hand of the Gestapo in the Andes." The hero (the author) of course comes out victorious, and looks forward to the time when the principles which he inaugurated in the colony will dominate the entire organization of South America. The book is entertainingly written despite the vast quantities of political propaganda which it contains. Readers in the United States will find the references to this country highly amusing.



JOURNEY TO THE WORLD'S END.

By Hakon Mielche. *William Hodge and Co., Edinburgh, London and Glasgow.* 12s. 6d. net. $8\frac{1}{2} \times 6\frac{1}{2}$; [12] + 297 + 16 plates; 1939.

This is an excellent example of the right way to write a travel book. The author is not a scientist, and there is very little strictly scientific description in his work. He simply got tired of the monotonous sort of life he had been living and went to Cape Horn because that was the most remote part of the world he could think of. The writer has great powers of description and a keen sense of humor, with

the result that he has produced a work of universal interest, that holds the attention of the reader just as firmly when reporting the life of the night clubs of Magallones as when describing the flamingoes and ostriches of Tierra del Fuego.

There is no authority, however, for combining the Spanish form of the Christian name of the circumnavigator with the Portuguese form of his surname thus: Fernando de Magelhaes. The Portuguese form of Fernando is of course Fernão. But good books are not wrecked by such details.



THREE GENERATIONS. *The Story of a Colored Family of Eastern Tennessee.*

By Charles W. Cansler. (Obtainable from the author, 1805 Brandau Ave., Knoxville, Tenn.). \$1.25. $8 \times 5\frac{1}{2}$; viii + 173; 1939.

This book endeavors to trace the changes in the social status of Negroes from ca. 1831 to the present. The accounts of the first and second generations are concerned mostly with the position of the slave and the free Negro just before and during the Civil War. The material regarding the third generation is chiefly autobiographical. The dominating thought of the book appears to be an appeal to Negroes to acquire more education, support Negro schools, and unite into organizations in order to elevate the position of the Negro in society. An interesting contribution.



PREHISTORY IN HAITI. *A Study in Method.* Yale University Publications in Anthropology Number 21.

By Irving Rouse. *Yale University Press, New Haven; Oxford University Press, London.* \$2.50. $9\frac{1}{2} \times 7$; 202 + 5 plates; 1939 (paper).

The author presents a new systematic technique for historical reconstruction in archaeological research. The scheme is applied to a reconstruction study of the prehistory of the Ft. Liberté region, Haiti. The Ft. Liberté artifacts were obtained by Dr. F. G. Rainey and the writer during a field trip to this region. Included in this

monograph are numerous photographs of the Ft. Liberté artifacts, distribution tables, maps, and bibliography.



ARQUIVOS DE MEDICINA LEGAL E IDENTIFICAÇÃO. *Publicação Oficial do Instituto de Identificação, Ano IX-N. 17.*

Published under the direction of Leonidio Ribeiro. Imprensa Nacional, Rio de Janeiro. 9½ x 6½; xxiii + 486 + 20 plates; 1939 (paper).

In July, 1938, the first Latin-American Congress on Criminology met in Buenos Aires. This volume contains the addresses, papers, and case reports presented at these meetings. Most of the papers deal with the legal and administrative aspects. Of interest to biologists and medical men are the two studies of L. Ribeiro, one on juvenile delinquency and the other a morphological study of a group of Negro criminals.



ZOOLOGY

A BIBLIOGRAPHY OF BIRDS. *With Special Reference to Anatomy, Behavior, Biochemistry, Embryology, Pathology, Physiology, Genetics, Ecology, Aviculture, Economic Ornithology, Poultry Culture, Evolution, and Related Subjects. Part 1, Author Catalogue, A to J, Publication 442; Part 2, Author Catalogue, K to Z, Publication 457.*

By Reuben M. Strong. Field Museum of Natural History, Chicago. \$11.00 for Parts 1 and 2. 9½ x 6½; 937; 1939 (paper).

The enormous amount of literature that has accumulated in ornithology makes this bibliography a valuable asset to those working on birds. The subtitle indicates the subject matter covered. Taxonomy and distribution have not been stressed, although important publications in this field have not been omitted. Paleontological titles preceding the appearance of Lambrecht's catalogue are included. The year 1926 was originally set as the limit of the literature covered, although later references have been added, but not so

comprehensively. In other fields the compiler has had to use his own judgment on the inclusion and exclusion of references, an attempt being made to select only those of value or from an accredited source. However, very few omissions were made with the older literature. In many cases the library in which the reference was found is appended—a valuable bit of information that will save many an hour of fruitless searching. An extremely important and valuable addition to ornithological literature.



POULTRY PRACTICE.

By Leland D. Bushnell, with the collaboration of Edwin J. Frick and Marvin J. Twiehaus and others. Veterinary Magazine Corp., Chicago. \$1.00; in lots of 25 or more, 80 cents. 10 x 7; 160; 1940.

The recognition of the poultry industry as a billion-dollar business and the realization of the unnecessarily high mortality among both young and laying stocks of fowls have stirred numerous groups of investigators into activity. The present volume of 34 papers by nearly as many authors, gives a summary of the research to the present time, much of which has been carried out at the Regional Poultry Research Laboratory at East Lansing Michigan.

The articles deal with the anatomy and the physiology of the fowl, as well as with the symptoms, diagnosis, etiology, cause, and in many cases, the cure, for numerous common diseases and pathological conditions. The most startling fact is that in many cases, even though the causes and the diagnosis of a disease are perfectly well known, there is as yet no reliable method of treatment or cure. A constant note of warning for poultrymen is sounded against home diagnosis and treatment of serious poultry diseases, and an attempt is made to show the necessity of calling in a well-trained veterinarian for proper diagnosis and treatment. The short bibliography and index will serve the volume well in the hands of the poultryman, the research worker, and the veterinarian.

PROCEEDINGS AND TRANSACTIONS OF THE
LIVERPOOL BIOLOGICAL SOCIETY, *Volume*
LII. Session 1938-1939.

Edited by R. J. Daniel, with the cooperation of S. T. Burfield and W. S. Laverock. University Press of Liverpool. 1 Guinea.

8½ x 5½; ix + 80 + 2 folding tables; 1939.

This report includes two papers which will be of interest to the student of fish migration. (1) Some notes on Irish Sea plaice—additional data derived from material collected at the Lancashire Sea-Fisheries Laboratory in the University of Liverpool during the period 1908-21 and first reported on in 1921. This material, which is concerned with the age, sex ratios, and distribution of fish during the different age periods, shows that the females generally leave the nursery when three years old and do not arrive at the spawning ground until four years old, while the majority of the males migrate directly to the spawning ground. (2) Salmon of the Cheshire Dee, 1937 and 1938. This is the first of a series of investigations (covering a 5-year period) on the annual adult salmon populations of the Cheshire Dee. Many tables exhibit data for both of these papers. Graphs, diagrams and reference lists are included.



THE LARVAL TREMATODA FOUND IN CERTAIN SOUTH AFRICAN MOLLUSCA: *With Special Reference to Schistosomiasis (Bilharziasis). Publication of the South African Institute for Medical Research No. XLII (Vol. VIII).*

By Annie Porter. South African Institute for Medical Research, Johannesburg. Free.

10½ x 7½; 492 + 83 plates + 1 map; 1938 (paper).

This very fine survey of the larval trematodes of South Africa contains, aside from the systematic descriptions, much general information concerning geographical distribution, morphology of cercariae (final larval stage of the worms), infestation of molluscs, man and some vertebrates, life cycle of a human schistosome, etc. The vast bulk of the work was done with

living material. It was found that some cercariae only emerged from the snails during relatively restricted times (6 A.M. to 7 A.M., others at 12 midnight to 2 A.M., and these usually were dead by 6 A.M.), but others passed out during all hours of the day. A complete list of the molluscs is given; also a lengthy table showing molluscan associations, number of specimens examined, and types of trematode infestations found. The student and particularly the investigator will find this comprehensive study with its numerous drawings, charts, and lengthy bibliography of great value. It would seem to have merited an index.



THE MARINE DEPOSITS OF THE ARABIAN SEA. *An Investigation into Their Distribution and Biology. The John Murray Expedition 1933-34. Scientific Reports. Volume III, No. 2.*

By H. G. Stubbings. British Museum (Natural History), London. 15s. 12 x 9½; 128 + 4 plates + 4 charts; 1939 (paper).

CRINOIDEA. *The John Murray Expedition 1933-34. Scientific Reports. Volume IV, No. 4.*

By Austin H. Clark. British Museum (Natural History), London. 2s. 12 x 9½; 22 + 1 plate; 1937 (paper).

The first of these surveys consists of 185 samples of deposits from 131 stations. Included in the report is the distribution of the main types of marine deposits obtained from earlier reports—also a survey of the region of Zanzibar. References, maps, and illustrations of sample deposits add to the usefulness of this very excellent report.

Sixteen species of Crinoids were collected (Indian Ocean). Of this number 5 were new and one represented a new genus. The author has included in the present list all of the crinoids known in the seas from the west coast of Ceylon to the west coast of India. A bibliography of 48 titles is included and illustrations of the five new species.

THE MIGRATION OF AMERICAN BIRDS.

By Frederick C. Lincoln. Illustrated by Louis Agassiz Fuertes. Doubleday, Doran and Co., New York. \$4.00. 10 x 7½; xii + 189 + 12 plates; 1939.

The author of this book has devoted many years to the subject of bird migration. His position in the Biological Survey has made him the focus for all bird migration records in the United States. From the wealth of data now in the files of the Survey the migration of North American birds is fairly well mapped out. Although the origin of migration is a problem not yet solved, the routes, time of arrival and departure, distances covered, etc., are all well known for most of our birds. The mechanics and dangers of migration, the flyways systems, the different types of migration are some of the major topics. In the chapter on bird banding is a series of the more interesting banding operations which reveal not only the remarkable distances traversed by the birds, but also give interesting clues to their duration of life. There are several color plates and maps.



LA MÉCANIQUE DU POISSON DE RIVIÈRE.

Qualités Nautiques du Poisson; Ses Méthodes Locomotrices; Ses Capacités; Ses Limites; Résistances du Fluide; Effet de la Vitesse, de la Pente; Résistance de Seuil.

By G. Denil. Goemaere, Imprimeur du Roi, Bruxelles. 9½ x 6½; 395; 1938 (paper).

In this account on the mechanics of fish the writer discusses first the shape and locomotion of the fish, admirably built for their aquatic existence; second, the physical obstacles imposed by the water which the fish has to overcome; and third, the application of known physical principles and laws of water and bodies in water to the construction of fish ladders that permit their crossing over man-made barriers. There are three forces working against the fish—that of speed of the water, the slope of the flow (the presence of such a force is elaborately described) and a force which the writer calls *résistance de seuil*. An important contribution to a little known phase of fish study, of necessity rather technical.

THE BOOK OF FISHES. *Revised and Enlarged Edition, Presenting the Better Known Species of Food and Game Fishes of the Coastal and Inland Waters of the United States.*

Edited by John O. La Gorce. National Geographic Society, Washington, D. C. \$3.50. 10 x 6½; 367; 1939.

No one with a grain of sporting blood can glance through the pages of this volume without wanting to try out his flies and plugs. But the book not only holds fascination for the angler but for the biologist as well. Descriptions and life histories of the most important of the marine inhabitants of the United States are presented by some of the foremost ichthyologists of this country. They tell of the anatomy, distribution, reproduction, methods of catching, and commercial importance of these forms, besides countless other points of interest. The chapter entitled "Market Fish Have Many Names" will be a revelation to the gourmet. The book closes with an interesting article on fossil fishes. The written material is augmented by about 400 excellent drawings in color and action photographs. There is a thorough index to the volume.



INTRODUCTION TO VERTEBRATE ZOOLOGY.

By William H. Atwood. C. V. Mosby Co., St. Louis. \$3.75. 8½ x 5½; 511; 1940.

One of the most complete textbooks of the vertebrates that has come to the reviewer's attention. The term "Vertebrata" is construed in the broadest sense to include the lancelets, the ascidians, and the Enteropneusta, which since the admission of King Phoronis himself, has become quite a home for incurables.

Within the phylum a great deal of attention is given to unusual forms, such as the ostracoderms, the lungfishes, the extinct amphibians and reptiles, the tinamores and the hoatzin (many systematists will disagree with the author's opinion of the taxonomic position of these), the exotic marsupials, the Galeopithecidae, etc. The embryology as well as the adult anatomy of all these is discussed, and various

theories of derivation are detailed. This is far more than a laboratory manual; it is a useful work of reference.



EYES IN THE NIGHT.

By Tappan Gregory. Thomas Y. Crowell Co., New York. \$3.50. 9 x 6½; xi + 243; 1939.

This volume includes nearly 50 night-time photographs of most elusive and beautiful wild animals—from the tiny field mouse to the mountain lion. Mr. Gregory, a Chicago lawyer, has made expeditions into Mexico and other out of the way places in quest of wild animals. He has photographed wolves in Louisiana, baby foxes in Illinois, black bear and deer in northern Michigan, as well as mice and squirrels in his own back yard.

The text describes the pictures and how they were achieved. Also there are detailed descriptions of different kinds of apparatus used. All of the photographs are interesting and excellent of their kind and many are unusually beautiful, especially those of the deer.



PRINCIPES DE ZOOLOGIE AGRICOLE. Collection Armand Colin No. 223.

By Paul Vayssière. Armand Colin, Paris. 15 francs (paper); 17.50 francs (cloth). 6½ x 4½; 224; 1940.

The great economic loss to agriculture which results from animal infestations inspired the publication of this volume. The author feels that his own country, France, is particularly backward in research in this field, and hopes that his review of the problems will direct attention toward their solution. He shows the complexity of the interrelation between plants and animals, and discusses the control of plant parasites by means of physical factors (lethal temperatures, etc.), biological factors (parasites of the destructive organism), and chemical factors. Further chapters describe the distribution and dispersion of agricultural pests and the problems encountered in dealing with nematodes and migratory insects.

NATURAL HISTORY AND METHOD OF CONTROLLING THE STARFISH (ASTERIAS FORBESI, DESOR). U. S. Department of the Interior. Bureau of Fisheries. Bulletin No. 31.

By Paul S. Galtsoff and Victor L. Loosanoff. Government Printing Office, Washington. 20 cents. 11 x 7½; 58 + 4 plates; 1939 (paper).

The sudden increase in the starfish population in shellfish areas has generally been regarded by oystermen as an "invasion." The erroneousness of this notion has been demonstrated by the authors of this bulletin, who have surveyed the numbers of starfishes and the changes in their distribution in Buzzards and Narragansett Bays, Long Island Sound, and lower Chesapeake Bay. The movements of starfishes are extremely slow, and quite limited in extent. Local increases in their numbers should be attributed primarily to the increased rate of propagation and survival of the local stock.



ANIMALS ARE LIKE THAT!

By Frank Buck with Carol Weld. Robert M. McBride and Co., New York. \$2.50. 8½ x 5½; 240 + 15 plates; 1939.

Once again "Bring 'Em Back Alive" Frank Buck writes of his animal acquaintances both roaming and behind bars. In this book he describes his elephant friends whom he considers the most intelligent of all beasts, devoting other chapters to the amusing antics of apes and monkeys, lions and tigers, and numerous other jungle inhabitants. The work is a record of continuous activity, of conquering and living in close quarters with animals both in captivity and in their native habitat, and contains much unusual and interesting information.



THE QUADRAT METHOD OF STUDYING SMALL MAMMAL POPULATIONS. Scientific Publications of the Cleveland Museum of Natural History. Volume V, Number 4.

By B. P. Bole, Jr. Cleveland Museum of Natural History, Cleveland. \$1.00. 9½ x 6; 63; 1939 (paper).

In the studies of small mammal popula-

tions, especially when dealing with total numbers present, various trapping techniques have been developed. These methods are reviewed by the writer who concludes, as a result of his own experiments and studies, that the quadrat method is the best. The larger the quadrat the more accurate the results. More than one quadrat should be used, but they should not be placed too close together, nor should any one encompass different ecological areas. The results of systematic trapping of small mammals in Ohio are summarized.



BRITISH BLOOD-SUCKING FLIES.

By F. W. Edwards, H. Oldroyd, and J. Smart. *British Museum (Natural History)*, London. 158. 10 x 6½; viii + 156 + 45 plates; 1939.

The blood-sucking flies of the British Isles are fully described in this beautifully illustrated volume. Each of the three authors has taken a separate sub-order (Nematocera, Brachycera and Cyclorrhapha) and has listed the species to be found within the prescribed range, their habits and peculiarities, and in some cases, described some new forms. In addition to the illustrations, there are keys and bibliographies that together make this volume a noteworthy contribution to the entomology of Great Britain.



FLEAS OF EASTERN UNITED STATES.

By Irving Fox. *Iowa State College Press, Ames, Iowa*. \$3.00. 8½ x 6; vii + 191; 1940.

Detailed descriptions of all the *Siphonaptera* found east of the one-hundredth meridian are given in this book. Numerous drawings show the principal identifying structures. In a brief introduction the author gives the general morphology, methods of collection and preservation, and methods by which these parasites can be controlled. In view of the medical importance of fleas and the general lack of information concerning them, the book will probably have ready acceptance.

VOICES FROM THE GRASS.

By Julie C. Kenly. Illustrated by Henry C. Kenly. *D. Appleton-Century Co., New York and London*. \$2.00. 7½ x 5½; xvii + 248; 1940.

Another book written for the young on the fascinating behavior of the insect world. Mrs. Kenly tells the story of the spider, the ant, the firefly and of many other familiar yet mysterious creatures. The book is documented and indexed and illustrated with simple black and white drawings.



THE TETRAPOD REPTILES OF CEYLON. Volume I. Testudinates and Crocodilians. *Ceylon Journal of Science. Colombo Museum Natural History Series.*

By P. E. P. Deraniyagala. *The Director, Colombo Museum, Ceylon; Dulau and Co., London*. Rs. 10, or in England, 15s. 9½ x 7½; xxxii + 412 + 24 plates; 1939.

Much careful work has gone into the preparation of this volume which discusses history of local herpetology, collecting, classification, orders of Reptilia in Ceylon, etc. The larger part of the report is concerned with the two sub-orders of Testudinata—Athecoidea and Thecophoroidea—and with the order Emydosauria. Many text figures and plates are included, also tables of measurements (62), a systematic index, glossary, a lengthy bibliography, and indexes of both English and scientific names as well as author's index.



THE AMPHIBIA AND REPTILIA OF OREGON.

By Kenneth Gordon. *Oregon State College, Corvallis, Oregon*. 50 cents. 10½ x 7½; 82; 1939.

Herein are given the description, range, habitat of the amphibia and reptiles known to occur in Oregon and a few that probably are to be found in that state. There are keys and illustrations as an aid in identification, a bibliography, as well as introductory notes on distribution, snake bites, etc.

A CONTRIBUTION TO THE HERPETOLOGY OF FLORIDA. *University of Florida Publication. Biological Science Series, Vol. III No. 1.*

By Archie F. Carr, Jr., *University of Florida, Gainesville.* \$1.35. 10 x 7; [4] + 118; 1940 (paper).

An annotated list, with notes on life histories, abundance, and range. There is an extensive discussion of the derivation and distribution of this fauna, a key, a bibliography, but no illustrations.



BIRDS OF EASTERN NEWFOUNDLAND. *Scientific Publications of the Cleveland Museum of Natural History. Volume IV, Number 2.*

By John W. Aldrich and David C. Nutt. *Cleveland Museum of Natural History, Cleveland.* 50 cents. 9½ x 6; 30; 1939 (paper).

The birds of eastern Newfoundland are listed with the description of two new subspecies, the Newfoundland black-capped chickadee and the black-backed robin. There is a bibliography and a brief introduction.



ZOOLOGICA. *Scientific Contributions of the New York Zoological Society. Volume XXIV, Part 4, Numbers 27-31.*

New York Zoological Society. Zoological Park, New York. \$1.40. 10½ x 7; 119 + 5 plates; 1939 (paper).



BOTANY

AMERICAN HUSBANDRY.

Edited by Harry J. Carman. *Columbia University Press, Morningside Heights, N. Y.* \$5.00. 8½ x 5½; lxi + 582; 1939.

A reissue of a volume that first appeared in 1775—author unknown. The soil, climate, agricultural products, and practices of English colonies in America are described in Nova Scotia, Canada, the Atlantic states, the West Indies, and the Ohio and Mississippi valleys. It is pointed out that the navigability of the

Mississippi and Ohio rivers together with the fertility of the soil and its suitability for raising valuable staples make this region one of great potential wealth.

Two critical reviews of the book, the first appearing in 1776 and the second in 1918, are included. The most probable author of the volume is discussed in the review (1918) by Lyman Carrier and in a report by Harry J. Carman. The former holds the author to be Dr. John Mitchell, a botanist who lived in both England and America. The latter holds that methods of historical detection must cause us to discard Dr. Mitchell and leave the writer in the limbo of the forgotten.



THE GENERAL ASPECTS OF THE VEGETATION OF EUROPE.

By Marietta Pallis. *Taylor and Francis, London.* 3s. 6d. net. 9½ x 6½; [6] + 66 + 1 folding table; 1939 (paper).

The main thesis of this study, with the vegetation of Great Britain, Roumania and Greece taken as representative of the state of the vegetation in Europe generally, is that, except above the altitudinal tree-level, the natural vegetation was forest and that grassland and other forms of degraded vegetation spread by the interference of animals and man. Among the author's conclusions and surmises are:

Schimper's forest climate necessarily antedates the dicotyledonous tree in the Upper Cretaceous. There has probably been a forest period since then—almost unbroken forest—in Europe at any rate, excluding the Ice Age of the Pleistocene, after which there was re-establishment of the forest as the dominant cosmic formation. . . . Primitive vegetation is more often simple with one dominant, but where the flora is rich there may be several. Degraded vegetation is usually complex, with no dominant, but instead a veering multitude of species. . . . Extinction may come through external causes or, it is suggested, through constitutional change—senescence—as regards both the vegetative and the sexual reproductive process.



FIELD TRIALS. *Their Lay-out and Statistical Analysis.*

By John Wishart. *Imperial Bureau of Plant Breeding and Genetics, School of Agriculture, Cambridge.* 2s. 6d. 10 x 8½; 36; 1940 (paper).

The amount of any given kind of seed at the disposal of a plant breeder is frequently very limited. And, as every experimenter knows, this makes it difficult to obtain data on yield that is free from experimental error on the one hand and from seasonal or soil differences on the other. A great deal of error and expense can be avoided, however, by careful planning of experiments. Some methods of arranging field trials are suggested in this bulletin, and correct methods of working-out and interpreting the resulting data are outlined. There are sections devoted to the methods of randomized blocks and Latin-square planting, to multiple-factor experiments, to "confounding," and to experiments with large numbers of varieties.



THE TRANSVERSE REACTIONS OF PLANTS.
Outlines of a New Interpretation of the Significance of Growth Hormones for Life-Processes in Plants.

By Georg Borgström. Einar Munksgaard, Copenhagen; C. W. K. Gleerup, Lund; Williams and Norgate, London. Dan. Kr. 7.50. 9½ x 6½; 230; 1939 (paper).

This publication outlines a hormonal interpretation of life-processes in plants. The discussion is based upon experimental work performed by the author and upon research work of others. The concept set forth is that reactions in plants can be fully explained by a transverse hormonal action. The response of the plant organism to its environment is the resultant of polar and transverse hormonal action. The polar component is, by and large, responsible for longitudinal growth. The transverse component is responsible for phototropic, geotropic, temperature, mechanical, and specific substance reactions. This hypothesis allows a new interpretation to be given to the mutual correspondence of external factors.

The text contains 38 figures, an extensive bibliography is present, and English, German, and Russian summaries are appended at the end of the report.

A MANUAL OF THE LIVERWORTS OF WEST VIRGINIA. Reprinted from "The American Midland Naturalist," Vol. 23, 1940.

By Nelle Ammons. The University Press, Notre Dame, Ind. (Obtainable from the Editorial Office of the American Midland Naturalist.) \$1.75. 9½ x 6; 164; 1940.

LIVERWORTS OF SOUTHERN MICHIGAN.

Bulletin No. 17.

By William C. Steere. Cranbrook Institute of Science, Bloomfield Hills, Mich. 50 cents (paper); \$1.00 (cloth). 9 x 6; 97; 1940.

Both of these manuals are excellent; that dealing with the liverworts of West Virginia (with its lengthy bibliography) is rather for the advanced student than for the beginner. The Michigan manual will be found an excellent introduction for those wishing a guide to the commoner members of the liverwort family. Both are illustrated and contain keys, glossaries, and indexes.



LA REPRODUCTION CHEZ LES PLANTES.

By Roger Heim. Librairie Armand Colin, Paris. 15 francs (paper); 17.50 francs (cloth). 6½ x 4½; 219; 1939.

A study of the reproductive processes of plants brings to light more facts concerning plant biology and natural history than that of any one of the other physiological processes. This fact is more fully appreciated when it is realized that the classification of plants, and particularly the higher ones, depends largely upon the morphological characteristics associated with reproduction. Upon this fundamental basis, M. Heim has developed a most interesting discussion of plant reproduction. The age-old principle of alternation of generations for each phylum of plants is discussed in the light of evolution, morphology, physiology, and cytology. The text is well illustrated and documented, and the factual material is brilliantly augmented by the abundance of pertinent examples drawn from the author's own experience.



BACTERIOLOGY. *Clio Medica.*

By William W. Ford. Paul B. Hoeber, Inc., Medical Book Department of Harper

and Bros., New York and London. \$2.50.
6½ x 4½; xi + 207; 1939.

Dr. Ford has written a chronological story of the growth of man's knowledge about bacteria. He presents not just the high lights alone—the classical experiments—but also the observations and deductions which are the foundations of the great discoveries. The picture of the changing relationships between bacteriology and other scientific fields, a fine study of give and take, is especially interesting not alone because Pasteur was first a chemist, but even more because of the important part played today by bacteriology in, for example, preventive medicine, therapeutics, the preservation of foods, and agriculture.



ADAPTATION AND ORIGIN IN THE PLANT WORLD. I. *Factors and Functions in Coastal Dunes.*

By Emmett V. Martin and Frederic E. Clements. Carnegie Institution of Washington, Washington, D. C. 50 cents. 10 x 6½; viii + 107 + 5 plates; 1939 (paper).

The prevailing assumption that xerophytism in plants is most marked by leaf transformation is attacked in this study. Quantitative measurements were made on plants growing in several dune habitats and in a control habitat. It was found that plants grown in fertilized soil have, on the average, thicker leaves. The number of stomata varied so greatly among the several species that it was impossible to formulate a general rule. The same was true as regards transpiration. Extensive tables of the values for habitats used in the course of this research are given; 57 titles are included in the bibliography, and 32 illustrations and 5 plates are appended.



ESPERIENZE SULLA PRODUZIONE DEGLI OLII PER VIA MICROBIOLOGICA Nel Quadro Autarchico dell'Approvvigionamento dei Grassi in Italia. I. *Il Lavoro Agricolo e l'Autarchia.*

By P. G. Garoglio and Raffaele Ciferri. Confederazione Fascista dei Lavoratori dell'Agricoltura, Roma. 3 Lire. 9½ x 6½; 35; 1940 (paper).

In this paper the authors give a summary account of a series of experiments designed to compare the fat content of several species and genera of fungi. Six species of *Mucor*, 6 species of *Penicillium* and 5 species of other assorted genera were cultivated under comparable conditions and the quantity and physicochemical properties of the fats extracted were assayed. The authors conclude that the commercial production of fats from microorganisms is feasible, and recommend its adoption as part of the present Italian efforts towards economic autarchy. A short bibliography is appended.



GROWING PLANTS IN NUTRIENT SOLUTIONS: or *Scientifically Controlled Growth.*

By Wayne I. Turner and Victor M. Henry. John Wiley and Sons, New York; Chapman and Hall, London. \$3.00. 9 x 6; xiii + 154 + 3 plates; 1939.

In order that the lay reader might better understand soilless plant culture, the authors have included in this book the fundamentals of plant physiology and of the necessary chemistry. Although a large part of the volume is devoted to nutrient culture on a commercial scale, the window-box farmer is not neglected. Detailed instructions are given for the construction of benches and tanks, and for the mixing and testing of formulae. The authors advocate replenishing used solutions rather than discarding them, and they include a chapter on the recognition of plant deficiencies. The written material is clarified by numerous photographs and diagrams.



EXPERIMENTELLE CYTOLOGIE.

By Hans H. Pfeiffer. *Chronica Botanica Co., Leiden; G. E. Stecher and Co., New York.* 7 guilders or about \$3.70. 9½ x 6½; xii + 243; 1940 (paper).

This work is confined entirely to the plant cell, its physical properties, morphology, aging and necrosis, and experiments with vital stains. Emphasis has been placed on the more recent studies. The author plans to treat the chemical, genetic and cytophysical aspects in later volumes.

The present work is Volume 4 of the *New Series of Plant Science Books*, edited by Frans Verdoorn.



MORPHOLOGY

FUNCTIONAL HUMAN ANATOMY.

By Cleveland P. Hickman. Illustrated by Frances M. Hickman. Prentice-Hall, Inc., New York. \$3.75. 9 x 6; xxxv + 501; 1940.

It would seem that there is just cause in the academic world for welcoming this excellent text. That there is need for such a volume requires no emphasis. Its aim is to present to students of elementary human anatomy a functional interpretation of bodily structures. No preliminary training in the biological sciences on the part of the student has been assumed. The material has been divided into two parts. The first emphasizes the descriptive and applied aspects of the subject; the second deals with the practical study which the student is called upon to do for himself. Since the student of elementary anatomy is not ready to dissect the actual structures of the human body, the practical study has centered around a mammal, such as the cat.

The illustrations have been made with considerable care and forethought. Much information of anatomical value will be found in the appendices, and the work concludes with a list of practical review questions, a glossary of technical terms, a list of references, and a carefully prepared and complete index.



A BRIEF ANATOMY OF THE TURTLE.

By Glenn A. Noble and Elmer R. Noble. Stanford University Press, Stanford University, Calif.; Oxford University Press, London. \$1.00. 8½ x 5½; viii + 48 + 21 plates; 1940 (paper).

The turtle, as a representative of the class Reptilia, has long been used in zoology and comparative morphology courses. This book, based on a study of the California mud turtle, *Clemmys marmorata*, is intended for use as a brief but adequate

laboratory guide in such courses. The first part of the book is devoted to a discussion of the organ systems; the latter part, to plates illustrating these systems. Most stress is laid on the muscular, circulatory, nervous, and skeletal systems; the digestive, respiratory, urogenital, and endocrine systems and the embryology of the turtle are treated in less detail. A bibliography is included.



PHYSIOLOGY AND PATHOLOGY

A HISTORY OF TROPICAL MEDICINE: Based on the Fitzpatrick Lectures Delivered before the Royal College of Physicians of London 1937-38. In Two Volumes.

By H. Harold Scott. Williams and Wilkins Co., Baltimore. \$12.50 per set. 9 x 5½; xix + ix + 1165 + 13 plates; 1939. This history of the so-called tropical diseases fittingly begins with the progress of hygiene in the navy, mercantile marine, and army (particularly the English), the personnel of which were among the first Europeans to come into contact with these diseases, and sometimes to cause their introduction into the home country. Instances are cited to show how expeditions, campaigns, and battles were lost due to the incapacity or death of troops by malaria, yellow fever, dysentery, etc., together with methods carried out to prevent these losses to the time of the Italo-Abyssinian war in which, among 500,000 Italian troops only 1241 cases of primary malaria and only 23 deaths from this disease were reported.

Then the author treats the diseases—malaria, blackwater fever, yellow fever, trypanosomiasis, leishmaniasis, leprosy, cholera, plague, undulant and relapsing fevers, melioidosis, dengue, amoebic dysentery and hepatitis, ankylostomiasis, and the avitamosic diseases—separately, with regard to early history, incidence and spread (including areas other than tropic), records of outbreaks, history of research on the causative bacillus and mode of transmission, measures for control and cure. Concluding chapters tell the story of the construction of the Suez and Panama canals, the rôle of the slave trade in the

spread of disease, and the lives of a few men with claims of renown in the field of tropical medicine and sanitation.

A philosophic trend, with particular emphasis on social and economic implications, runs throughout the book. Much of it, particularly references to personalities connected with research on causative agents and methods of control, reads like a romance—the triumph over yellow fever and the building of the Panama canal are the classical examples.

This is a solid, scholarly work, but it is regrettable that the bibliography (only 8½ pages) has not been extended. Author and subject indices have been supplied.



THE MAMMOGENIC HORMONES OF THE ANTERIOR PITUITARY. I. The Duct Growth Factor. University of Missouri. Agricultural Experiment Station. Research Bulletin 310.

By A. A. Lewis and C. W. Turner. University of Missouri, Columbia. Free. 9 x 6; 72; 1939 (paper).

There appear to be two factors in the mammogenetic hormone secreted by the anterior pituitary, one of which stimulates the growth of the duct system and the other the lobule-alveolar system of the mammary glands. It is with the former of these that this study is concerned. Among the findings obtained from 545 cattle pituitaries assayed for their content of the duct growth factor of mammogen were:

The mammogen content of AP from pregnant dairy and beef cows was found to be low in early and late pregnancy, rising to a peak at about 150 days. . . . Non-pregnant cows were found to have an appreciable amount of mammogen in the pituitary. The content was highest in lactating dairy cows. . . . Two beef heifer groups, with corpora lutea, had 40 to 60 per cent more mammogen hormone per AP than did pregnant beef cows at the 150 day peak. A similar group of beef heifers with only follicles in the ovaries had a low content of mammogen in the AP. . . . Dairy steers had 83 per cent as much mammogen per AP lobe as did dry non-pregnant dairy cows, with follicles. Beef steers weighing 500 to 700 and over 700 pounds had a low content of mammogen in the AP. . . . Fetal pituitaries contained an appreciable amount of hormone.

Data are also reported for smaller numbers of rabbits, mice and ground squirrels. A bibliography is appended.

DIE BIOLOGISCHE REAKTION. Eine funktionelle Analyse und Synthese biometrischer Werte zur Zahlenmässigen Erfassung von: Allergie, allgemeiner Resistenz, spezifischer Resistenz, Krankheitsintensität, Extensität aktiver Herde, Immunität.

By O. H. Bucher-Trümppler and C. C. Hofflin-Karwatzki. Verlag Hans Huber, Bern. 42.80 francs; R.M. 25.70. 10½ x 7½; 267; 1939.

This treatise grounds itself upon a sort of quantified pathometric index for tuberculosis, derived fundamentally from differential leucocyte counts with and without stimulation by tuberculosis. The scheme for computing and combining the variables involved is a complicated one, that is explained with something short of easy and complete clarity. The bulk of the book is devoted to detailed discussions of individual cases of tuberculosis, with colored graphs of bewildering complexity showing the course of the variables and derivative biometric data from them accompanying the text account of each case. The interest of the book is for the clinical worker in tuberculosis. It obviously represents an enormous amount of careful, serious and sincere work. But in our opinion it will be necessary, before the author's ideas can be intelligently applied or evaluated by others, for someone competent in mathematics, statistics, and clinical medicine to take time off and present a simple, clear, and straightforward account of just exactly what the technique is, and how it is to be used. The present treatise, in short, is obscure. It is beautifully printed.



ON OXIDATION, FERMENTATION, VITAMINS, HEALTH AND DISEASE. The Abraham Flexner Lectures, Series Number Six.

By Albert V. Szent-Györgyi. Williams and Wilkins Co., Baltimore. \$2.00. 8 x 5½; xi + 109; 1939.

Five lectures delivered by the author in 1939 at Vanderbilt University are embodied in this volume. The first four summarize his well-known biochemical investigations on oxidation and cellular and tissue respiration. Taking as his starting point the elementary formula for

the oxidation of carbohydrates the author almost painlessly introduces the reader to what is probably the most complex aspect of biochemistry. In clear and concise terms he first describes the fundamental researches of Warburg and of Wieland and then outlines his own studies which, among other things, led to the discovery of ascorbic acid. The last lecture contains an interesting discussion of vitamins and their bearing on health. Two somewhat novel views on the subject are advanced. The first is that the lack of a vitamin forming mechanism in man is another indication of his descent from a creature that lived in a region rich with vegetation. The second refers to the human requirements of vitamins. The belief is expressed that the administration of larger than the usual therapeutic amounts of vitamins would serve to increase bodily vigor and promote health; therefore, a plea is made for more investigations on the optimum dosages of vitamins for man.



FOOD CONTROL: Its Public-Health Aspects. A Manual for Regulatory Officers, Food Technologists, and Students of the Food Industry.

By James H. Shrader. John Wiley and Sons, New York; Chapman and Hall, London. \$4.00. 9 x 5½; ix + 513; 1939.

The large consumption of processed, preserved, and stored food by urban populations has made their control an important public health measure. The writer points out that it is not only the duty of public health administrations to see that untainted food reaches the consumer but that these should also be within certain nutritional limits. The book is primarily a practical manual of food inspection and food laws enforcement. It should be exceedingly valuable to public health workers, food inspectors, and food industrialists. The subject matter presented will aid in conserving funds by showing the most practical methods of control for given expenditures. Two appendices dealing with the equivalence of vitamin units and a digest of the new federal

statutes concerning foods, drugs, and cosmetics are present. The book is well documented and indexed.



PICTURE OF HEALTH.

By James Clarke. Illustrated by Guy Rowe. The Macmillan Co., New York. 60 cents. 7½ x 5; 125; 1940.

It is strange but true that most discussions of health deal with the subject from a negative aspect; that is they usually deal with the cause, cure, and economic importance of *bad* health. In the present volume, however, the author has developed his discussion around the positive aspects of health—his thesis being that health is the culmination of all normal physiological processes and activities.

The volume is intended for popular consumption. The discussions of the digestive, circulatory, respiratory, excretory, and nervous systems together with their activities and functions are quite frank, yet entirely devoid of the unpleasantness which many lay readers associate with a study of their "insides."

The simplicity of the terminologies, the pertinence of the examples and analogies, the clarity of the illustrations, as well as the list of books for further reading tend to make the volume a noteworthy contribution in the field of health as related to every-day living.



STUDIES IN THE DEVELOPMENT OF YOUNG CHILDREN.

By Nancy Bayley. University of California Press, Berkeley. 35 cents. 8½ x 5½; vii + 45; 1940 (paper).

In the introduction the author states that a "study of growing children must be as continuous as growth itself." It was with this idea in mind that the ten-year studies on the mental and physical development of 61 Berkeley infants (30 girls and 31 boys), born in the same year 1928-29, were carried out. All the children selected were born in hospitals; all were white, and nearly all, of North European or early American stock; also, only those infants whose parents expected to make

Berkeley their homes for many years to come were included in the study. In spite of this latter fact, the number of children diminished until at the end of the ten-year period there were 48.

The subjects studied include home and family factors, early illnesses, growth in size, trend of bone development, growth in intelligence, development of personality, and such factors as would have retarding or favoring influences on development. The results as they were obtained from month to month and year to year are briefly compiled; graphs and photographic plates are included.



FOOD AND LIFE. *Yearbook of Agriculture* 1939.

U. S. Department of Agriculture. U. S. Government Printing Office, Washington.

\$1.50. 9 x 5½; xv + 1165; 1939.

Readers so literal as to expect these yearbooks to be annual summaries of governmental statistics will be pleasantly surprised to learn that they deal with different topics from year to year, and in a remarkably attractive way. The yearbooks for 1936 and 1937 summarized what is known about the improvement of crops and livestock through breeding; the one for 1938 devoted similar efforts toward illuminating the subject of "soils and men." The latest one, an encyclopedic collection of 58 essays, seeks to be as informative as possible about man's present knowledge of nutrition. One-third of the book discusses the nutrition of human beings; two-thirds of it, dealing with the nutrition of animals, contains much information of fundamental value with regard to human nutrition. A 94-page summary serves as an introduction.



VIRUS AND RICKETTSIAL DISEASES: *With Especial Consideration of Their Public Health Significance. A Symposium Held at The Harvard School of Public Health, June 12-June 17, 1939.*

Harvard University Press, Cambridge; Oxford University Press, London. \$6.50. 9½ x 6; xi + 907; 1940.

Students of infectious diseases will welcome this summary of the work so far done in the field of virus and rickettsial diseases. Our knowledge of these disease agents has increased so rapidly and on so many fronts that it is now impossible for any one person to be completely familiar with much more than his own sector. These 34 papers by authorities, most of them writing from personal experience, were given in a symposium at Harvard in the summer of 1939. It was thought best to include reviews of the literature of those phases of the study not under active investigation at the school, in order to present an integrated survey of this interesting field. Each paper, nevertheless, is complete in itself, making the volume a useful reference work as well.



RECENT ADVANCES IN MEDICAL SCIENCE. *A Study of their Social and Economic Implications. The Rede Lecture Delivered Before the University of Cambridge on 28 April 1939.*

By Sir Edward Mellanby. The Macmillan Co., New York; The University Press, Cambridge. 75 cents. 7¼ x 4¾; 62; 1939.

This lecture gives us a very clear picture of the general improvement in health, made possible by increased medical knowledge. He calls our attention to the discovery of numerous synthetic drugs successfully used in the cure of disease and control of symptoms, and to continually increased understanding of the causes of disease. He shows that life expectancy is reaching higher figures, while infant mortality is sinking to lower ones and that between the two the average age is increasing, thus creating new problems in social and economic fields. The book is interesting and instructive, and bestirs thought on the problems presented.



THE MEDICAL CAREER and Other Papers.

By Harvey Cushing. Little, Brown and Co., Boston. \$2.50. 8 x 5½; vii + 302; 1940.

In this book, published posthumously, is presented a collection of 16 essays by Harvey Cushing. The first seven are

addresses delivered at various medical occasions and deal with topics of medical interest, contemporaneous and historical. Throughout them runs the humanistic trend which so strongly characterizes Dr. Cushing's other writings. The last nine essays are brief biographical sketches of men whose contributions to medical thought and practice have been outstanding: namely, Welch, Beaumont, Halsted, James Ford Rhodes, George Strong Derby, Perry Williams Harvey, Haller, Councilman, and the Mayos. The essays are characterized by warmth and charm. We particularly recommend the volume to medical students. The publishers announce that coincident with its publication they are bringing out, in uniform size, a new edition of Dr. Cushing's *Consecratio Medici*.



FETAL AND NEONATAL DEATH. *A Survey of the Incidence, Etiology, and Anatomic Manifestations of the Conditions Producing Death of the Fetus in Utero and the Infant in the Early Days of Life.*

By Edith L. Potter and Fred L. Adair.
University of Chicago Press, Chicago.

\$1.50. 7 $\frac{1}{2}$ x 5 $\frac{1}{2}$; xv + 207; 1940.

Since the neonatal death rate has remained practically stationary in comparison to the great decline in post-neonatal mortality, there has been great interest aroused in the causation and prevention of these deaths. Unfortunately the true cause of death is in many cases erroneously determined unless an autopsy is performed. As an aid to arrive at an accurate cause of death, this book first describes the normal fetus and infant, then the methods of a post-mortem examination. There then follows a discussion on the major causes of death—attributable mostly to prematurity, birth trauma, anoxemia, infection, and unfavorable exposure immediately after birth. A chapter on the special pathology of the new born concludes the volume.



NUTRITIONAL STUDIES IN SHANGHAI. *A report upon the nutritional status of certain Shanghai Groups 1937-39, dietary surveys and*

a study of the value of various food supplements. Chinese Medical Association. Special Report Series No. 12.

By H. C. Hou, P. G. Mar, T. G. Ni and B. E. Read. Chinese Medical Association, Bookselling Dept., Shanghai. \$1.00. 9 $\frac{3}{4}$ x 6 $\frac{1}{2}$; [4] + 92; 1939 (paper).

After the outbreak of the Sino-Japanese hostilities in Shanghai (August, 1937) the number of refugees rapidly grew until upwards of 200,000 were gathered in empty houses and makeshift camps. Mostly they were fed by charity. This interesting report is concerned with diet and nutritional deficiencies among refugees; nutritional supplements for refugee children; their height and weight measurements; height-weight measurements of refugee children given soybean milk, etc. The last three chapters are: Physical measurements of Cantonese school boys in Shanghai; Height-weight measurements of Shanghai school children; A nutritional survey of three groups of Shanghai families. Numerous tables and graphs are included in the text and each chapter is summarized and concludes with a bibliography.



RECENT ADVANCES IN NEUROLOGY. *Fourth Edition.*

By W. Russell Brain. The Blakiston Co., Philadelphia. \$5.00. 7 $\frac{1}{2}$ x 5 $\frac{1}{2}$; ix + 364; 1940.

The fact that this is the fourth edition of a book which made its first appearance only eleven years ago attests to the high regard in which Dr. Brain's work is held. In the present edition the subject matter has been largely rewritten, and seven new chapters have been incorporated. Subjects which are now discussed for the first time or in which important advances have been made include: the pathogenesis and treatment of headache, the functions of the frontal lobe, vitamin deficiencies in relation to nervous disorders, diseases due to neurotropic viruses, muscular disorders associated with thyroid disease, and the treatment of meningitis with sulphanilamide. The illustrations, the excellent and numerous references, and the complete index add to the value of this book.

AN INTRODUCTION TO EXPERIMENTAL HUMAN PHYSIOLOGY

By W. W. Tuttle and G. Clinton Knowlton.
C. V. Mosby Co., St. Louis. \$1.50.
10½ x 7½; 138; 1939 (paper).

The paramount idea in presenting the material included in this laboratory guide is to enable the beginner in physiology to familiarize himself with the techniques involved in demonstrating the fundamental phenomena of this subject. Insofar as possible experimentation is placed in the hands of the student; and, where practicable, the students themselves are used as subjects for the experiments. A total of 44 experiments are presented with space provided for the answers to the questions at the end of each experiment. The appendix furnishes many important and helpful details of procedure. The manual has references throughout to Zoethout's *Textbook of Physiology*.

**MEDICAL EDUCATION IN THE UNITED STATES 1934-1939. Prepared for the Council on Medical Education and Hospitals of the American Medical Association.**

By Herman G. Weiskotten, Alphonse M. Schwitalla, William D. Cutter and Hamilton H. Anderson. American Medical Association, Chicago. \$1.00. 10½ x 7½; [12] + 259 + 4 charts; 1940 (paper).

This book contains the report of a survey of the medical schools of the United States and Canada, made under the guidance of the American Medical Association through its Council on Medical Education and Hospitals. The survey has been most intensive, and the result is a particularly complete analysis of the administrative organization, educational requirements, hospital connections and clinical facilities, student responsibilities, and general qualifications of the schools. A study of distinct value to men and women desiring to enter the medical profession, in determining which school may satisfy their individual preference.

**JEWISH CONTRIBUTIONS TO MEDICINE IN AMERICA: From Colonial Times to the Present. Second Edition, Revised and Enlarged.**

By Solomon R. Kagan. Preface by James J. Walsh. Boston Medical Publishing Co., Boston. \$3.50. 8½ x 6; xxxi + 794; 1939.

This lengthy survey of the scientific activities of outstanding American-Jewish physicians from colonial times to the present gives an excellent picture of the extent to which Jewish contributions have helped to advance medical science. It is arranged as a series of biographical sketches and historical facts in chronological order. The appendices include an outline of Jewish medical chronology and a list of Jewish medical institutions. The latter part of the book forms a supplement to the first and main body. Photographs and bibliography and separate indices for each of the two divisions are included in the volume.

**CANCER MORTALITY IN THE UNITED STATES.**

I. *Trend of Recorded Cancer Mortality in the Death Registration States of 1900, from 1900 to 1935.* U. S. Public Health Service. Public Health Bulletin No. 248. II. *Recorded Cancer Mortality in Geographic Sections of the Death Registration States of 1920, from 1920 to 1935.* U. S. Public Health Service. Public Health Bulletin No. 252.

By Mary Gover. Government Printing Office, Washington. 10 cents each. 9½ x 5½; I, vi + 58; 1939 (paper). II, vi + 74; 1940 (paper).

A valuable addition to cancer records. Both studies add considerable statistical knowledge to that already accumulated on the occurrence of cancer in the white and colored races in the United States. The data collected must increase the speculative assumptions as to the causes of the disease, and intensify research as to the possible similarity of reasons for susceptibility in individuals.

**TRAITÉ DE L'IMMUNITÉ DANS LES MALADIES INFECTIEUSES. Deuxième Edition.**

By Jules Bordet. Masson et Cie, Paris. \$3.30. 10 x 6½; v + 879; 1939 (paper). This long overdue second edition of one of the great classics of immunology adds 160

pages to the text. The bibliographic documentation has been improved in respect of the method of citation, but still leaves something to be desired by American standards. There is no index, a deplorable omission in an important reference work such as this. But even with these defects the volume will be welcomed by all immunologists as setting forth the mature views of its distinguished author.



ELEMENTS OF HUMAN PHYSIOLOGY.

By *Miriam Scott Lucas*. *Lea and Febiger*, Philadelphia. \$4.50. 9½ x 5½; 400; 1940.

The present volume represents an attempt to provide a suitable presentation of human physiology for pre-professional courses which do not require the detailed discussions found in medical texts and is written from the point of view of the student and teacher of physiology—not from the viewpoint of a specialist. The discussion is presented in four parts: movement and support, integration in the body, metabolism and water balance, and reproduction and endocrine function. The illustrations are well-chosen and the index is very complete. There is no bibliography.



PROBLÈMES ACTUELS DE BIOLOGIE GÉNÉRALE ET DE PATHOLOGIE EXPÉRIMENTALE.

By *Henry Bénard*. *Masson et Cie*, Paris. \$1.05. 9½ x 6½; 176; 1939 (paper).

This book contains six papers containing brief historical surveys and summaries on the present state of knowledge of several topics of physiological and pathological significance, namely: cellular respiration, cyanhydric intoxication, experimental pancreatic diabetes, mode of action of insulin, glucose and its deterioration, and experimental rachitis and vitamin D. Written in a clear and fluent style, in spite of the amount of material crammed into relatively small spaces, the book will be of interest to biologists as well as medical men. It lacks bibliographies.

THE PERCEPTION OF LIGHT. *An Analysis of Visual Phenomena in Relation to Technical Problems of Vision and Illumination.*

By *W. D. Wright*. *Chemical Publishing Co.*, New York. \$2.50. 7½ x 4½; [6] + 100; 1939.

This analysis of visual phenomena in relation to technical problems of vision and illumination does not pretend to exhaustiveness, but is more in the nature of an essay. The book begins with a general account of visual phenomena and then discusses vision at low and high intensities and visual sensations. There is an especially timely and helpful chapter on glare, including an illuminating discussion of the headlight problem. The concluding chapter presents the results of some recent researches in the field of light perception. There is a list of references and an index.



CARBOHYDRATE METABOLISM. *Four papers presented in a Symposium held at the meeting of the American Physiological Society at Toronto, Canada, April 29, 1939. Reprinted from Endocrinology, Vol. 26, February 1940.*

Association for the Study of Internal Secretions, Boston. \$1.00. 10½ x 6½; 285-351; 1940 (paper).

This little booklet embodies four papers presented in a symposium held at the April, 1939, meeting of the American Physiological Society, at Toronto, Canada. They are concerned with glycogen breakdown and synthesis in animal tissues, and with the relationships between the liver, the adrenal cortex, and the pituitary gland and carbohydrate metabolism. Excellent bibliographies are appended to each paper presented.



BIOCHEMISTRY

HAIR-DYES AND HAIR-DYEING CHEMISTRY AND TECHNIQUE.

By *H. Stanley Redgrove and the late Gilbert A. Foan*. *A New Edition Completely Revised by H. Stanley Redgrove and J. Bari-Woollis*. *Chemical Publishing Co.*, New York. \$5.00. 8½ x 5½; xiv + 205 + 10 plates; 1939.

This book, first published in 1929 under

the title *Blonde or Brunette*, is a comprehensive and detailed account of hair dying and its various phases. The title has been changed from the original as the authors found "that many folk were misled by the original title in mistaking the book for a novel dealing with the claims of two rival beauties." The first part of the book is a general discussion of the structure and pigments of hair; Part II discusses dyes and bleaches specifically; Part III the art of hair dying; and Part IV goes into the causes of grey hair and supplies generous hints to those who wish to avoid premature greyness. These include not to worry "even about grey hair," and to "choose your hairdresser with care, and if he hasn't read this book, give him a copy." A bibliography has been included, but an index is lacking.



FRUIT PECTINS: Their Chemical Behaviour and Jellying Properties. *Food Investigation, Special Report No. 48.*

By C. L. Hinton. *Chemical Publishing Co., New York.* \$1.75. 8½ x 5½; vii + 96; 1940.

This report is based on work carried out during a period of several years by members of the staff of the British Association of Research for the Cocoa, Chocolate, Sugar Confectionery and Jam Trades, and presents a study of the variations in the chemical properties of pectins, as extracted from fruits, as a basis for an eventual explanation of their jelly-forming behavior. The free acidity, the pH of the solution, the proportion of alkaline ash constituents, the methoxyl content, and the reducing power towards alkaline iodine all were found to vary widely. In view of the variations found in the properties of the pectin specimens, it is claimed that "pectin" must be regarded as a generic term covering a wide range of minor variations of molecular composition. The book contains a list of references, but no index.



BIOLOGICAL PRODUCTS.

By Louis Gershenfeld. *Romaine Pierson Publishers, New York.* \$4.00. 9½ x 6½; ix + 244; 1939.

Persons engaged in public health, medicine, and the biological sciences will find this book a convenient source of information. The uses, dosages, preparations, and standardizations of antitoxins, serums, vaccines, immunizing toxins, toxoids, bacteriophage, allergens, etc., are adequately presented. The biological principles of handling, shipping, and storing of the products both finished and during the course of preparation are treated throughout. Federal statutes concerning both preparation and sale are also given. The lack of material upon hormonal products will be missed by many.

Extensive bibliographical references are incorporated in the body of the text. A fine index is appended. The illustrations, although interesting, add little to the subject matter covered.



MINERAL METABOLISM. *American Chemical Society Monograph Series.*

By Alfred T. Shohl. *Reinhold Publishing Corp., New York.* \$5.00. 9 x 6; x + 384; 1939.

To describe the rôles of various minerals in the structure and function of the human body is the aim of this monograph, which was sponsored by the American Chemical Society. The field as a whole is in a phase of such rapid expansion that a simplified account rather than an exhaustive one, and an interpretation from the point of view of his own special interest, is all that the author has hoped to accomplish. He discusses the mineral composition of the body, of secretions, excretions, and internal secretions. The book is in excellent balance, and it is exceptionally informative.



REPORTS OF THE BIOCHEMICAL RESEARCH FOUNDATION OF THE FRANKLIN INSTITUTE. *Vol. V, 1938-1939.*

Franklin Institute, Philadelphia. 9½ x 7; collection of reprints.

A further collection of reprints (cf. Q.R.B., Vol. 13, p. 374) on various phases of biochemistry, histo-chemistry and physico-chemistry, with particular relation to the study of disease and medicinals. Included

also are two statistical papers, one on cancer and the other on lead poisoning, by F. L. Hoffman.



SEX

SEX AND LIFE. *Forty Years of Biological and Medical Experiments.*

By Eugen Steinach. The scientific values adapted to the lay reader by Josef Loebel.

The Viking Press, New York. \$3.75. 9½ x 6½; x + 252 + 53 plates; 1940.

Steinach's account of the development of his ideas and investigations on the physiology of sex has been written for the layman and, according to the publisher's blurb, for "men and women, particularly those in the middle and late years, who will learn from this the startling possibilities of adding years of mental and physical vigor to life." As is to be expected, therefore, this volume is mainly concerned with the rejuvenation or reactivation operations and views associated with the author's name. Aided by beautiful illustrations, a vivid and colorful story is told of the author's well-known researches on castration and gonad implantation that finally led to the vasoligation experiments. The results obtained on man by this method are duly amplified and the first and other alleged successful operations are described in detail. The author indirectly admits that there are a number of competent investigators who question his results and theories but he seems to be more bewildered than angered by such skepticism. Unfortunately for his scientific reputation, the tone and objectives of this book will not serve to diminish this skepticism.



STERILITY AND IMPAIRED FERTILITY. *Pathogenesis, Diagnosis and Treatment.*

By Cedric Lane-Roberts, Albert Sharman, Kenneth Walker, and B. P. Wiesner. Foreword by Rt. Hon. Lord Horder. Paul B. Hoeber, Inc., Medical Book Dept. of Harper and Bros., New York. \$5.50. 8½ x 5½; xx + 419; 1939.

The four co-authors of this volume have brought together the present-day knowl-

edge of sterility, its pathogenesis, diagnosis, and treatment. A glance at the bibliography reveals that much of the literature is very recent, with the result that while great progress has been made, there are still many facts to be proven. It is to the credit of the writers that their approach to the problem is very sound and that they exercise due caution in their conclusions and recommendations.

A wealth of material is presented on both male and female sterility and impaired fertility. The constitution of normal and abnormal semen, examination and interpretation of endometrial and vaginal smears, faulty coital techniques, psychological, hormonal, and surgical treatments and therapeutics are only some of the pertinent topics ably discussed and illustrated.



SEXUAL PATHOLOGY. *A Study of Derangements of the Sexual Instinct. New Revised Edition.*

By Magnus Hirschfeld. Authorized translation by Jerome Gibbs. Emerson Books, Inc., New York. \$2.95. 9 x 6; 368; 1940.

This is a new edition, stated to have been revised, of the English translation of a well-known work. It consists, in the main, of a running discussion of cases from the late author's practice as a sexologist. Hirschfeld was a pioneer in the movement for sexual reform, along with Forel and Havelock Ellis. The sort of material embodied in this book was foundational stuff for their crusade. But now it seems dated and a little boring.



BIOMETRY

A BIBLIOGRAPHY OF THE STATISTICAL AND OTHER WRITINGS OF KARL PEARSON.

Compiled by G. M. Morant, with the Assistance of B. L. Welch. Biometrika Office, University College, London. 6s. net. 10½ x 7½; viii + 119; 1939.

In this volume the authors have carefully assembled in chronological order the list of the writings of Karl Pearson, annotated each title, and have also added a subject

index. The 648 titles have been classified into five sections. The first and most important includes 406 titles and concerns the writings on the theory of statistics and its applications to biological, social and other problems. The following four sections include the list of papers and books on pure and applied mathematics and on literary, historical and academic subjects, and the list of prefaces, notes, and reviews which have appeared in scientific journals. A sixth section contains information about the places of publication of the syllabuses of the various series of lectures given by Pearson. Biometricians and human biologists, in general, will quickly realize the great usefulness of this volume. Those who are too young to have followed as contemporaries the publications of Pearson will undoubtedly obtain from a perusal of this book a clearer idea of the broad scope of his intellectual powers and certainly a stimulus to study at first hand his contributions. The authors are to be congratulated for the evident thoroughness with which they have accomplished their task.



THÉORIE ANALYTIQUE DES ASSOCIATIONS BIOLOGIQUES. Deuxième Partie. Analyse démographique avec application particulière à l'espèce humaine. Actualités Scientifiques et Industrielles 780. Exposés de Biométrie et de Statistique Biologique XII.

By Alfred J. Lotka. Hermann and Cie, Paris. 45 francs. 10 x 6½; 149; 1939 (paper).

Lotka summarizes in this monograph some of the more salient features of the contributions made by him and others towards the development of what may be called mathematical demography. He presents the formulae for the analytical description of human population growth, on the basis of several assumptions, and of the principal elements related to growth such as natality, mortality and age composition. Other special aspects of demography treated in this book concern natality in successive generations, size of family and extinction of lines. Although all of these topics have been more adequately discussed in the author's previous English

publications, the student of the subject will appreciate the advantage of having the formulae brought together. There is a bibliography which, as the author admits, is rather incomplete.



ADVANCES AND APPLICATIONS OF MATHEMATICAL BIOLOGY.

By Nicolas Rashevsky. University of Chicago Press, Chicago. \$2.00. 7½ x 5; xiii + 214; 1940.

Rashevsky's recent book *Mathematical Biophysics* (reviewed Q.R.B. Vol. 14, p. 106) contributed to the development of a relatively new field of science. The present extends further the application of the "approximation" method.

The approximation method attempts to take into account the size as well as the shape of the cell, the coefficient of diffusion for the substance inside the cell, the permeability of the cell membrane, and the coefficient of diffusion of the external medium in arriving at an average concentration of substance inside the cell. The average value will be found somewhere between the periphery and the center of the cell, and is expressed independently of the local structure variations which may be taking place, i.e., the movement of the centrosomes, the activity of the chromatin material, the appearance of the spindle fibers, etc. It is on this average value for the concentration of cell substance that Rashevsky bases his discussions of diffusion phenomena, cell respiration, cell division, cellular growth, cellular forms and movements, and protoplasmic streaming.



THE VARIATE DIFFERENCE METHOD.

By Gerhard Tintner. Principia Press, Bloomington, Ind. \$2.50. 9½ x 6½; xiii + 175; 1940.

Through the studies of Yule especially, statisticians have long been made aware of the difficulties which surround an analysis of time series. Yule was also one of the first to investigate the problem with some degree of thoroughness and, following Student and others, to develop the variate difference method. This method

has also been employed and further developed by the economists, among whom one may mention particularly Anderson and Zaycoff. On the basis of their researches the author studies and discusses in this book the analysis of variance and covariance of the random element of a time series. The analytical procedure outlined consists of an application of the product-moment correlation method and that of Fisher's variance theory to conditions arising from the sequences of differences between the successive terms of a time series. To facilitate the computations, which by this procedure involve very large numbers, the author has prepared useful tables which are included in the text.



AN INTRODUCTION TO MODERN STATISTICAL METHODS.

By Paul R. Rider. John Wiley and Sons, New York; Chapman and Hall, London.
\$2.75. 8½ x 5½; ix + 220; 1939.

Enormous and rapid advances have been made in the field of statistics, the greatest progress having been made in the theory of small samples. Most of this theory, according to Rider, has been developed and unified by R. A. Fisher, whose methods are therefore of value to all investigators who are obliged to deal with comparatively few observations. Rider's book expounds the most widely used of these methods, illustrating their application by comparatively simple numerical examples, so that the underlying principles are not lost to sight in a maze of arithmetical computations. The language of the calculus as a medium through which these methods may be communicated has not been avoided. In the earlier chapters of the book the fundamental concepts of statistics are developed; the later chapters are principally concerned with Fisher's methods; and some of Fisher's tables are reprinted as an appendix.



THE BULLETIN OF MATHEMATICAL BIOPHYSICS. *Volume 2, Number 3, September, 1940.*

Edited by N. Rashevsky. University of Chicago Press, Chicago.

This number contains the following papers: A generalization of Cunningham's extension of Stoke's law for a force on a sphere, by Gale Young; Physicomathematical aspects of some problems of organic form, by N. Rashevsky; Contributions to the mathematical biophysics of organic form. III. The formation of shell-shaped cellular aggregates, by N. Rashevsky; On the formal theory of nerve conduction, by Alvin M. Weinberg; A note on the horopter, by Alston S. Householder; A general fluid circuit theory of active chloride absorption, by H. C. Peters.



MATHEMATICS IN BACTERIOLOGY.

By Otto Rahn. Burgess Publishing Co., Minneapolis. \$1.75. 10½ x 8½; iii + 63; 1939.

It is the object of this booklet to help the student to acquire an understanding of the quantitative interrelationships of the various life functions of bacteria by solving problems. Subjects under discussion include: unrestricted and restricted cell division and fermentation, growth of individual organisms, disinfection, statistics in bacteriology, and the use of graphs. Ample material has been provided for a class of students to practice formulas and equations. A sharp line is drawn between the terms growth and multiplication, since the author feels that the two are definitely different things.



PSYCHOLOGY AND BEHAVIOR

DANGEROUS THOUGHTS.

By Lancelot Hogben. W. W. Norton and Company, New York. \$2.75. 8½ x 5½; 283; 1940.

Hogben has brought together in this volume a series of essays dealing with his beliefs and theories on a variety of subjects related to social behavior. The title of the book derives from the author's realization that in times such as these it is dangerous not to be a partisan of either the Right or the Left in matters of political

ideologies. Of the fifteen essays that constitute this book, eight deal with problems of how to popularize science particularly so that the biological principles of human behavior may be better understood. Four essays are concerned respectively with comments on John Wilkins, William Petty, Havelock Ellis, and an assorted group of Scotch natural scientists. In the remaining three the author expounds again his views on social problems. An epilogue written after September 1, 1939 closes the book. "At last," he points out, "we have got the war against Hitlerism, the war for which the Labour Party has been clamouring during five years of frustration and the extinction of any vigorous constructive policy of domestic reform." This well expresses his judgment on the rôle played by the English Labor party to bring about the present European war. He concludes with the hope that the "Left intellectuals" will now abjure their errors, reenter the fold of democracy and help in the fight for the preservation of intellectual freedom. In this and all of the essays we are made aware of the author's command of language and of his wit and also of the internal conflict faced by the humanitarian biologist who seeks to apply his science to the study of human social phenomena.



WE CALL IT HUMAN NATURE.

By Paul Grabbe. *Worked out in Cooperation with Gardner Murphy.* Harper and Bros., New York and London. \$2.50. 9½ x 7½; [8] + 120; 1939.

The author of this interesting volume has hit upon something new in the field of presentation of scientific material. His ingenious and novel graphic methods of discussing the fundamentals of psychology have been found by well-known psychologists to be completely sound, as well as revolutionary—so much so that one of the leading psychologists of the day, Gardner Murphy, has participated in the preparation of the text, and has written a beginning note on "How this book came to be written."

The factual material is authentic and

well documented, with a note of careful differentiation between what is established fact, and what is theory. The abundance of illustrative material, and the clear presentation of data in simple, everyday language, make the book not only readable, but intensely interesting to the lay as well as to the professional reader.

The master theme, which is neatly interwoven throughout the entire thesis, is that of the necessity of the individual, if he wants to live anything like a contented and sane life, to achieve some measure of harmony with his environment. In studying and conquering the physical world, the author believes that we have neglected the study of our social world. A note of doom is sounded for our civilization unless we are able to fathom predatory and anti-social man to the extent of reaching a basis for good-will, cooperation, mutual understanding and mutual respect.



THE PSYCHOLOGY OF EXCEPTIONAL CHILDREN.

By Karl C. Garrison. *The Ronald Press Co., New York.* \$3.25. 8 x 5½; xiii + 351; 1940.

This book by the professor of psychology at North Carolina State College, is designed primarily for principals, teachers, and parents on whom the responsibility for guiding the development of exceptional children rests. Three general groups of exceptional children are considered: the gifted, the retarded and the physically handicapped. This last group includes children with defective vision, hearing or speech, children of lowered vitality, and left-handed and crippled children. The orientation of the book is against educating all children in a mechanical manner, against focusing attention exclusively on those factors in a given child which makes him exceptional, and towards the viewpoint that the personality of each child, regardless of what variation from average he may present, functions as a whole in his continual drive to maintain a satisfactory relationship to his environment. His education, therefore, should be adapted to his in-

dividual capacity and needs. The material presented is up to date and the book should prove of value as an introduction to the subject matter. There are four appendices, and author and subject indices.



THE INTER-RELATIONSHIP OF MIND AND BODY. *The Proceedings of the Association, New York, December 27th and 28th, 1938.*

By the Association for Research in Nervous and Mental Disease. Editorial Board: Foster Kennedy, Angus M. Frantz and Clarence C. Hare. Williams & Wilkins Co., Baltimore. \$6.00. 9 x 6; xx + 381; 1939.

This is a testimonial volume in memory of Dr. Frederick Tilney. It is a report of a symposium in which twenty-two authorities in various fields of nervous and mental pathology participated, and the discussion that ensued upon the presentation of each contribution. None of the participants except Foster Kennedy has adhered at all closely to the subject of the symposium as announced in the prospectus, and which also serves as the title to the present work. The result is a collection of highly technical essays on various phases of abnormal mental states and the conditions that produce them, instead of an integration of dualistic philosophy such as the title would lead one to suspect.

There is an extensive but not exhaustive bibliography at the end of each chapter, and an index of ten pages at the end of the book.



A COMPARATIVE STUDY OF THE SYSTEMS OF LEWIN AND KOFFKA WITH SPECIAL REFERENCE TO MEMORY PHENOMENA.

By Sylvia H. MacColl. Duke University Press, Durham, N. C. \$1.50. 9 x 6; vii + 160; 1939 (paper).

This study presents a polysyllabic comparative analysis and discussion of the psychological concepts and systematizations of Lewin and of Koffka, the latter selected as representative of the *Gestalt* point of view. The life-space of Lewin,

based on a mechanical conception of nature, with emphasis on substance rather than function and tension as the "causal" reality is contrasted with the psychological field of Koffka which is based on functional relationships and organization. The various problems of memory are analyzed and the bearing of each of the two systems on these problems is considered. It is found that neither system deals completely with all memory phenomena.

The study is of academic rather than practical interest. It is thorough-going and scholarly, but would benefit by simplification in vocabulary and general presentation. A bibliography is included.



DELAYED REWARD IN DISCRIMINATION LEARNING BY CHIMPANZEES. *Comparative Psychology Monographs. Vol. 15, No. 5. Serial No. 77.*

By Austin H. Riesen. The Johns Hopkins Press, Baltimore. \$1.00. 10 x 6½; 54; 1940 (paper).

This monograph, from the Yale Laboratories of Primate Biology, presents a study of learning in chimpanzees when the reward for the correct discrimination of a stimulus is delayed to a point in time after the stimulus has terminated. Two control and three experimental animals were used. The method of investigation is described in detail and the results presented in detail and discussed. It is found that when reward is delayed more than a few seconds, visual discrimination learning is difficult or impossible, as compared with learning when the reward is immediate. This is a well-devised study and a sound contribution to the literature of animal behavior. There is a bibliography.



**DE OMNIBUS REBUS
ET QUIBUSDEM ALIIS**

THE PHILOSOPHY OF PHYSICAL SCIENCE. *Turner Lectures 1938.*

By Sir Arthur Eddington. The Macmillan Co., New York; The University Press, Cambridge. \$2.50. 8½ x 5½; ix + 230; 1939.

There are but few words that have suffered more from overwork and abuse than the term philosophy. To Eddington it means the generalizations derived from observations. The process by which generalizations are arrived at is epistemology. It is clear that while other defects may impair a philosophy whose epistemology is flawless, it is impossible to establish a sound philosophy upon an unsound epistemological base.

Eddington devotes more than half his book to a discussion of various phases of epistemology. Not until he feels that he has laid an unassailable foundation does he ask the question whose answer embodies the whole of his philosophy of physical science, "Is the bung-hole part of the barrel?" If the question be answered in the affirmative it appears that a barrel without a bung-hole is only part of a barrel. But a barrel without a bung-hole is greater than a barrel with one. Therefore the part is greater than the whole, and the first half of one of Euclid's axioms collapses like a flat tire. (The second half, that the whole is equal to the sum of its parts is retained by Eddington, but he makes it clear that the algebraic sum is referred to).

Now if to a bungless, and therefore incomplete barrel be added a bung-hole, that which is added is a negative quantity of wood. Euclid would have avoided the hypotheation of the negative quantity by answering that the bung-hole was not part of the barrel, which would be thoroughly consistent with a philosophy based on the observation of such tangible objects as barrels, rather than on the subatomic particles of modern quantum physics. But we know today that atoms are constructed of electrons and various other kinds of trons which when added together frequently neutralize each other. Therefore, some of these particles must have negative mass, but none have it absolutely. Negativeness is a matter of relativity. And neither did Euclid understand the relativity theory.

From this beginning Eddington goes on to draw some conclusions that seem highly esoteric, such that the number of chemical elements in the universe is equal to the number of dimensions, and that the

number of particles in the physical universe is equal to the number of elements doubled 257 times. The result of this computation he sets out, and it is quite remarkable, but not more so than the man who figured it.

The present work is of much greater significance than the author's earlier one in which he discusses the relation between mysticism and science but it is not likely to have so many readers, as the thought is too profound for the average man to grasp.



THE PHILOSOPHY OF POWER: *First Principles.*
By Donald Murray. Williams and Nor-
gate, London. 12s. 6d. net. 8½ x 5½;
336; 1939.

The Philosophy of Power is built on the first and second laws of thermodynamics, being and becoming, growth and decay, and the belief that we live in a "Dualistic Diverse, and not in a Monistic Universe." The author considers himself "one of the great seers in direct line of apostolic succession from Kant and Spencer," Kant being the first of the great Actualist Philosophers, Spencer the second, and himself the third. *The Philosophy of Power* is based on Spencer's doctrines and the author's aim is to modernize Spencer—"to dot his 'i's' and cross his 't's' and translate his words into the modern thermodynamical phraseology." However, this work is almost entirely devoted, as the Spencerian philosophy is not, to problems of human welfare and the application of the two great generalized laws of thermodynamics, pressure energy and velocity energy, to such problems.

The author endeavors to debunk mathematics and those of its exponents who are trying to solve the riddle of existence by converting the universe into a mathematical proposition. He contends that this, the probability law, raises "the question of God versus Chance, . . . and Chance is denial of the existence of the thing called God." The author feels that this belief in the existence of God is "the fundamental basis for the well-being of men."

COMPOUNDING IN THE ENGLISH LANGUAGE.
A Comparative Review of Variant Authorities With a Rational System for General Use and A Comprehensive Alphabetic List of Compound Words.

By Alice M. Ball. H. W. Wilson Co.,
 New York. \$2.50. 9½ x 6½; x + 226;
 1939.

Those who are in any way concerned with the writing or the editing of manuscripts are constantly puzzled and disturbed by the inconsistencies in the rules for the compounding of words which are set forth by various dictionaries and manuals. Miss Ball, as lecturer on editing and as co-author of the Style Manual of the Department of State, has made the study of compounding her particular field and has now put forth a guide destined to have an important place on the reference shelves of all working libraries.

The first part is taken up with a discussion of the general principles embodied in the various American and English dictionaries and style manuals. This part is planned chiefly to show the chaotic condition which has existed in the compounding of words, and the need for logical and simple rules to clarify the situation. This is followed by a section on a rational system of compounding, that is the most important part of the book, for here are presented the rules and principles, with explanatory remarks and examples, which have so long been needed. Unfortunately most of us will tend to neglect this part and consult the section which follows—Alphabetical list of compound words (something over 100 pages long)—which tells at a glance the proper form to use. A list of authorities cited and an index complete this useful volume.



SCIENCE AND EVERYDAY LIFE.

By J. B. S. Haldane. Lawrence and
 Wisbart, London; The Macmillan Co.,
 New York. 5s. net in England; \$2.00
 in America. 7½ x 4½; 284; 1939.

Haldane is of the firm belief that much scientific knowledge is without practical application because it is not made available to the lay reader. This collection of 70 articles represents the first 16 months'

output of weekly articles (published in *The Daily Worker of London*) on science for popular consumption. In each article, the author, in his own words, "...attempted to do two things. I have tried to give a few facts which are not yet to be found in textbooks, and which a student leaving a university with an honours degree would not be expected to know. And I have tried to bring these facts into relation with everyday life." Anyone acquainted with Haldane's previous writings will fully realize his complete adequacy in achieving these two aims. Though much of the material is drawn from British sources, the underlying themes will find application in the lives of people from every country of the world. The material is presented clearly, simply, and in a very "human side of science" fashion.



SCIENCE FOR THE WORLD OF TOMORROW.

By Gerald Wendt. W. W. Norton and
 Co., New York. \$2.75. 8 x 5½; 316 +
 39 plates; 1939.

This is a commentary on those elements in the life of today that are to build the world of tomorrow. The turmoil of politics and the confused emotion of persons and peoples are absent—their place in the headlines is not their place in history. Wendt believes that man's outstanding achievement has been in the use of his intelligence to improve the environment of human life. He further feels that this in itself is *science*. Thus defined, science is a major social force, and we may evaluate our civilization by examining the rôle of science in it. This he proceeds to do. He discusses life in the age of science, sources of wealth and power, transportation, communication, the home and its importance, food, medicine and health, necessary luxuries, the use of leisure, and finally the scientific attitude. The book is beautifully illustrated with many views of the New York World's Fair and others chosen for their special appropriateness. An index is provided.

A HISTORY OF SCIENCE IN CANADA.

Edited by H. M. Tory. The Ryerson Press, Toronto. \$2.50. 9½ x 6½; vi + 152; 1939.

At the 1938 meeting of the American Association for the Advancement of Science at Ottawa, nine men contributed papers on the rise and development of the major fields of pure science in Canadian laboratories. These papers, now collected in book form, indicate how substantial and significant Canadian research has been and is. Samuel Beatty outlined the progress of mathematics, A. Norman Shaw the advance of physics, W. E. Harper the history of astronomy. Frank Dawson Adams dealt with Canadian geology, W. Lash Miller with the beginnings of chemistry, Frère Marie-Victorin with botany, and F. R. Dymond with zoology. Both Leo E. Parisean and J. J. Heagerty spoke for Canadian medicine. Finally an introduction has been contributed by H. M. Tory, director until recently of the National Research Laboratories.



THE FRAME OF THE ANCIENT GREEK MAPS:
With a Discussion of the Discovery of the Sphericity of the Earth. American Geographical Society, Research Series No. 20.

By William A. Heidel. American Geographical Society, Broadway at 156th St., New York. \$2.50. 8 x 5½; x + 141; 1937.

No Greek maps have come down to us. We know that they had maps and a few descriptions in contemporary literature, such as Homer's oft-quoted statement that the river Oceanus flows round the world, are our only source of knowledge of what these maps must have been like. Aristotle's description of the torrid, temperate, and frigid zones has no bearing on the matter, for he derived them from mathematical rather than from cartographical considerations.

The author has gone over the literature with a fine tooth comb, and assembled everything that throws any light on the matter. The book is, of course, highly technical but lucidly written, and is an interesting treatise on a matter that occupies but a small place in modern thought.

SCIENCE IN YOUR LIFE.

By John Pfeiffer. Illustrated by Ludwig Mactarian. The Macmillan Co., New York. 60 cents. 7½ x 5; [6] + 109; 1939.

This little book is a brief story of the many wonders we have learned to accept unquestioningly in our modern living. Working up from the early Egyptians and Galileo, the author, science editor of *Newsweek*, carries us step by step to the radio in the living room, the electric refrigerator in the kitchen, the wireless and the telescope and to the many other mysterious conveniences of the modern age. He touches briefly on the science of modern warfare, which has increased the power to kill, but he ends on an optimistic note, "... this power need not be used in the future," he says, "only three centuries separate Galileo and television. And there are still millions of years to go."

**MODERN METHODS AND MATERIALS FOR TEACHING SCIENCE.**

By Elwood D. Heiss, Ellsworth S. Obourn and C. Wesley Hoffman. The Macmillan Co., New York. \$2.50. 8½ x 5½; x + 351; 1940.

The principles set forth in this book are most applicable to primary and secondary school teaching. The first section presents an analysis of the various methods of teaching science. It discusses lectures, text books, laboratories, demonstrations, and reading. The final section lists the sources from which flat pictures, models, charts and posters, films, books, and periodicals may be obtained. An excellent aid to the beginning teacher in the organization of his courses.

**WHAT YOU WANT TO KNOW ABOUT DEVELOPERS: Fine Grain and Otherwise.**

By Edmund W. Lowe. Camera Craft Publishing Co., San Francisco. \$2.50. 7½ x 5½; 175; 1939.

PHYSICS IN 1939.

By Thomas H. Osgood. Reprinted from Journal of Applied Physics, Vol. 11, No. 1, pp. 1-17, 1940.



RAYMOND PEARL

June 3, 1879 - November 17, 1940

THE QUARTERLY REVIEW of BIOLOGY



THE PRINCIPLE OF COOPERATION IN BEHAVIOR

By WILLIAM GALT, PH.D.

The Lifwynn Foundation

I

THE object of the present paper is to report briefly some of the data which indicate that groups or species of animals, including man, constitute organismic integrations—that they do not represent a mere collection or agglomeration of individuals. My purpose is to cite some of the biological facts which support the view that the species man, as also species of animals lower in the phylogenetic scale, originally constituted a unified totality in which the activities of the component individuals were throughout motivated by the sovereign principle of behavior inhering in the species as an organismic whole.

In speaking on this subject I am not unaware that I am treading on dangerous ground. The problem in regard to the social integration of mankind is a delicate and much debated one. Herbert Spencer's analogy which regarded human society as an organism made up of individuals, just as the body of the individual is made up of cells, has justly received much criticism from psychol-

ogists and sociologists alike. Obviously human societies as they exist to-day are not bound together by cooperative principles such as characterize the inter-functioning parts or organs of the single individual. Spencer's conception was tinged with the sentimental and was not supported by biological evidence. For this reason such concepts as those advanced by Spencer have been dubbed the "group fallacy" and are habitually discredited before they are examined.

Many developments, however, have taken place in the biological and sociological fields since Spencer's time. The biologists have gathered much objective, incontrovertible data on the importance of social interdependence and cooperation throughout animal forms, the ethnologists and anthropologists have stressed the existence of social integrity and of internal coordination in the life of primitive tribes, and the scientific world has in general turned more to the study of functioning wholes, having realized that the part is wrongly conceived and interpreted when studied as an atomistic element isolated from the whole of which it is an integral constituent.

Among those who have contributed to the development of this trend one thinks especially of Lashley (23) and his students in the field of brain physiology; of Goldstein (17) in the neurological field; of Wertheimer (35), Koffka (19), Köhler (20), and Wheeler (36) in psychology; and of Woodger (39), Bertalanffy (3) and Spemann (33) in genetics and in biology proper. One of the most significant advances toward a new interpretation as regards development and behavior on the physiological or anatomical level has been made by G. E. Coghill (12, 13, 14). Prior to the careful observations of Coghill and his co-workers it was generally accepted that the first reactions of the developing animal in relation to the environment were of the nature of discrete responses of a reflex type, and it was further thought that in the course of the animal's development these reflexes were secondarily integrated with one another, thus insuring coordinated behavior in the organism. Coghill, however, observing chiefly *Amblystoma*, and Minkowski (27) the behavior of the human foetus, have shown that such a view is completely ungrounded in fact. They offer evidence to indicate that the first behavior in the developing organism is of a type that involves the reaction of the organism as a whole, and they show that the discrete, reflex type of response develops secondarily from this total reaction by a process of individuation. Even after the individuation of reflexes has occurred, the total action-pattern retains sovereignty over the partial patterns of the healthy organism. Coghill has further shown that the motor components of the nervous system are completed before its sensory connections have been formed. This indicates that early behavior is

spontaneous, that it arises from within the organism and is not called forth by outside stimulation. This investigator has thus brought a formidable challenge to stimulus-response psychology and its various mechanistic concepts.

In psychiatry and sociology the adoption of the newer, more organismic viewpoint has been slower, and the opposition to it more deeply entrenched. The most determined attempt that I know of to bring concepts in these spheres into alignment with the generally changing conceptions in other fields of science has been made by Dr. Trigant Burrow and his associates. In a communication published in *The Journal of the American Medical Association* as early as 1914 Burrow (6) stressed the social nature of the neurosis and the inadequacy and unreliability of psychiatric criteria which classified some individuals as normal and others as neurotic. As a result of submitting the social group itself to a rigid and inclusive analysis, he has in subsequent writings consistently insisted that so-called normal processes, because of their deviation from biologically consistent behavior, stand in as great need of a critical and exhaustive study as do the processes of the obviously neurotic individual. And by normal processes Burrow means the processes of himself, myself, yourself. He does not refer to normality as some vague generality existing in some remotely abstract sphere. In Burrow's organismic view, normal social processes are essentially of one piece with the bizarre behavior of the neurotic patient. The processes in the patient are not alien to or fundamentally different from those processes which habitually receive social credence and corroboration. From the basis of his inquiries, such categories as psychiatrist

and patient, normal and neurotic represent a formulation that is too static and absolutistic to fit into a relativistic view of behavior and its disorders. These conventional categories proved satisfactory only so long as each individual was looked upon as a discrete action-centre without intimate motivational connections with others of his species.

Burrow was thus forced by his experimental investigations of groups to apply an organismic view to human behavior and its disturbances. His position is that originally man as a species represented a unit, a whole, just as a herd of animals or a colony of ants or bees is regarded to-day as a supra-individual complex with emergent properties. The primary basis of motivation for man's behavior had its origin in the species, and this motivation was always in relation to species solidarity. The individual, as a separate motivational unit, was but a conceptual abstraction. As the result of a bio-social *faux pas*, however, the individual has been split off in motivation and feeling from his biological group. He has assumed an arbitrary isolation and individuation which are quite out of agreement with existing biological data. Contrary to our beliefs, our fancies and our cherished suppositions, the individual does not constitute the unit of social motivation and behavior. He no more represents the unit of social behavior than the discrete reflex represents the unit of physiological behavior. The social group, the race or species, is the fundamental unit. The behavior of the individual can only be sane and effective when it is in alignment with this principle. This conception of Dr. Burrow's rests upon firm, biological ground. It possesses in no sense a sentimental, religious or mystical connotation.

II

It will be readily seen that such a change in frame of reference must alter very fundamentally our study and interpretation of behavior. As a matter of fact, Burrow's researches in human behavior must lead to a reorganization of concepts in the field of man's interrelational function in much the same way that Coghill's studies have reorganized earlier views in regard to behavioral development in animals. For in the field of man's interrelational or social organization and behavior, the accepted viewpoint to-day is analogous to that held by neuro-embryologists in regard to the organization of behavior in animals prior to the researches of Coghill. The individual is to-day conventionally looked upon as the primary element, the fundamental unit out of which social units and social behavior are secondarily built. The child at birth is assumed to be filled with anti-social tendencies and to be imbued with instinctive ego-drives which are directed toward self-satisfactions antagonistic to others of his kind. The child is thus conceived of as starting life as a self-centered and socially disruptive unit. As a result of contact with the social group about him—first with his parents and later with the wider social community—these destructive, anti-social trends are either sublimated, repressed or disguised, so that the individual succeeds in getting along with others with a certain degree of external harmony. We hear much, then, about the socialization of the individual. Indeed this function is considered the all-important task of social education.

But we may ask how the data which we have from child psychology fit in with this concept. At the very outset we will probably recall that Piaget's

interpretation of the development of speech in the child is in alignment with this traditional sociological and psychiatric view. Piaget (31) holds that the first type of speech to appear in the child is ego-centric speech. It is speech not in relation to others but in relation to the child himself. The speech of the child is supposed only gradually to lose its ego-centricity and become social speech as a result of impact with the social forces about him. In a recent article, however, Vigotsky (34) furnishes experimental data to support the contrary view, namely, that speech when it first appears in the child is essentially social in nature and becomes more ego-centric as the child grows older. He considers ego-centric speech as a transition from the social activity of the child to his individual functions, from cooperative activity to the child's own individual activity. The latest experimental results and interpretation in regard to the development of speech in children lend no support, then, to the customary conception of the child as an ego-centric and asocial being. On the contrary, these results support the view that the appearance of ego-centric trends in the child is not due to his intrinsic organization, but rather that they are secondarily acquired.

To pass to other evidence from child psychology, Lewin (22) has emphasized that for the child the boundary between the self and the environment is less defined than for the adult and that the 'I' or self is only gradually formed in the second or third year of life. Other investigators have also referred to the surprisingly slow development in the child of the sense of the 'I' or self, and have laid stress upon the fact that one of the most difficult concepts which the child has to master in his early years is

the idea of himself as a separate, localized being, or as an individualized totality in himself. This is a particularly striking and interesting finding, especially when we consider the circumstance that from the background of our present culture the child is exposed from birth to the explicit and implicit assumption on the part of parents and the social milieu that the individual self or 'I' represents the unit of social function, that it is a dynamic totality and is only connected superficially with others through the rather secondary and artificial process of socialization. Now, if the child were by his original nature ego-centric and asocial, as the majority of students hold, it is difficult to explain why the concept of the 'I' or self should present such difficulties for him. It would naturally be supposed that, if this were the case, such a concept would be his guiding principle and would be the earliest personality-constellation to make its appearance. The very fact that personalistic concepts appear at a relatively late ontogenetic period in the development of the child lends much support to the view that such concepts are not in alignment with the natural growth processes of the child's organism but are rather in the nature of conditioned responses which are imposed by the child's contact with the world of adults.

In other words, in the course of its development the child does not go through a process of socialization but, quite the contrary, the process is one that more and more renders him asocial. To avoid being misunderstood let me expand this statement somewhat and explain just what I mean. There is no question but that the growing child is trained in the social amenities, the cultural customs and the types of behavior expected of him in different social situations. But my point

is that this training is on a secondary, superficial or conditioned level. It is subsequent and parallel to a process in which there is a weaning of the child from the sense of biological continuity and solidarity with his kind, and the establishment within him of a sense of personal identity, motivation and authority which of its nature must be in conflict with the identity and motivation of others of his social group. Expressed differently, the total social behavioral pattern which is the biological heritage of the human infant, as it is of other animal species, is disrupted, and an undue individuation takes place. This individuation, which in the course of time sets up an autonomous individual with private hopes, desires, wishes, gains and losses, of necessity brings about severe conflict when the desires of two or more elements or individuals happen to interfere with one another. The incentives to behavior have inadvertently become tied up with the individual as an arbitrary centre of action and motivation rather than with the social group as such a centre.

The findings of a number of other investigators give weight to our organismic thesis. Lack of space prohibits more than a very cursory reference to them. Recent observational and experimental studies by Crook (15) and by Alma Frank (16) report that there is a disruption of physiological coordination of function and the appearance of awkward part-responses as the child grows older. As a result of a great deal of experimental work with children in which they were placed in different types of social situations, Charlotte Bühler (4, 5) points out that cooperative behavior among children is more primary than the competitive response in that it much outweighs the latter in the early years of life. Using an experimental situation that would favor the expression of com-

petition, she found that this type of response did not make its appearance until about the third year of life. Gardner and Lois Barclay Murphy (29, 30) have also emphasized the presence in the young child of socially coordinating trends. Such observations will make it increasingly more difficult to adhere to our present psychological and sociological conception of the child as an ego-centric, antisocial being who is welded into the social pattern only by the force of pressure.

III

There are two other fields from which I should like to draw material corroborative of the thesis developed by Burrow. First is the field of anthropology or ethnology. Competent observers of life among primitive peoples have stressed the coordination and social solidarity of these groups, and the remarkable lack of individualism and competition among them. Kropotkin (21) supplies a wealth of material concerning this point. Authorities are in rather general agreement that life among primitive groups is universally based on tribal unity, and that the concept of individualism, as we are familiar with it, is meaningless to them. This seems to be one reason why contact with civilization plays such havoc with primitive peoples. It tends to destroy tribal unity and solidarity. Numerous writers such as Melville (26), Mead (24, 25), Heard (18), Benedict (2) and Rivers (32) have stressed the extent of social integration and co-operation among primitive tribes. Archeologists have also called attention to the fact that in unearthing the burial grounds of early cultures they have found very few implements of a warlike nature. From the background of the findings of these excavations they have come to the conclusion that tribes of early, prehistoric man lived on relatively friendly terms with

one another, and that they were by no means as pugnacious and warlike as are social groups to-day. While I am fully aware that a number of anthropological authorities still adhere to the individualistic viewpoint, it would seem that the more recent anthropological, ethnological and archeological students are in agreement in indicating that unbridled individualism is a modern growth, that it is not characteristic of primitive mankind.

The other general field from which I should like to draw supporting evidence is that of the comparative behavior of animals lower in the evolutionary scale than man. As we know, as early as 1890 Kropotkin (21) stressed the importance of the factor of mutual aid in animal life and gave numerous instances of this principle and its effectiveness in securing the survival of the species. He pointed out that even in his concepts of struggle for existence and survival of the fittest Darwin had consistently stressed the fundamental principle of cooperation in the species.

From his wide observation of animal life Kropotkin gives numerous instances of cooperation, mutual aid and social integration among insects, birds, and mammals. More recently Allee (1), gathering his observations for the most part under controlled experimental conditions, has shown the beneficial effects and the survival value of aggregations in widely divergent animal groups. There is not the opportunity at the moment to cite examples, but I should like to quote a few statements from the summary chapter of Allee's book.

"The potentiality of social life is inherent in living matter, even though its first manifestations are merely those of a slight mutual interdependence, or of an automatic cooperation which finds its first biological expression as a subtle binding link of primitive ecological biocoenoses. . . . Evidently," he says, "mutual interdependence, or automatic cooperation, is sufficiently widespread among the animal kingdom

to warrant the conclusion . . . that it ranks as one of the fundamental qualities of animal protoplasm, and probably of protoplasm in general."

Other biologists have also emphasized the fundamental nature of social aggregations among animals. To name but a few, we may mention Wheeler (37, 38), Morgan (28) and Child (10). As a result of his study of plants, Clements (11) insists that the same conceptions are applicable here.

While the observations and insight of these investigators have been unfailingly keen and comprehensive when observing groups made up of animals and of plants, they have seriously faltered where they have attempted to carry over their conclusions to civilized human communities. They have attempted to compare the family, the nation, the church, political parties and other social institutions with such organismic wholes as are represented by animal societies. But it is obvious that such social affiliations are not of the same order. The cooperation and interdependence which we found characteristic of biological foundations are not operative in these sophisticated social groups. Such groups operate from individualistic principles of behavior and not for the good of the community as a whole. Through his finding that man as a social organism is suffering from a racial neurosis Burrow has brought this anomaly in man's social behavior into line with biological data generally. As I have already indicated, he does not use the term neurosis figuratively. He actually means that man as a biological animal is definitely disordered in respect to his social and bionomic adjustment. This conclusion is not one that was lightly arrived at. It resulted from a painstaking and exhaustive analysis of social groups in experimentally controlled situations continuing over a period of fifteen years. As a result of investigating the so-called normal ideas, beliefs, wishes,

emotions, motivations, etc. characteristic of our daily social interchange, it was found that the social reactions of man which are habitually accredited as normal are, from a position of unbiased observation, as distorted and as lacking in biological reality as the isolated responses of the neurotic patient. The normal individual, like the neurotic, was found to be constantly thinking and acting in terms of his individualized self. He has established an image of himself as an isolated unit of behavior with private values, wishes and motivations, and this same image dominates his social interrelations.

The social neurosis, then, goes hand in hand with the undue individualization that has taken place in civilized man. The social institutions which man has constructed are built about his mistaken conception of himself as the essential motivational unit. These institutions, therefore, do not have the synthesis and organismic properties we found characteristic of social groups among animals and plants. In human groups we invariably find that discord, conflict, a blatant sentimentality or an esoteric mysticism are their guiding principles. Such groups are limited in their viewpoint. They have an axe to grind. They are in disharmony, conflict or competition with some other group. But man is still an animal. His biology is his most fundamental and ineradicable property. He has not permanently lost his biological heritage of cooperation and of true social integration. The neurosis, if socially recognized, can be corrected. The overtly individuated element or individual can again be brought under the control of the primary action-centre of the race or species.

IV

In the preceding section I have cited some of the evidence from the fields of

child development, comparative psychology and anthropology as it lends substantiation to the conception of social groups as organismic wholes and as it supports the thesis of the social basis of man's consciousness. Psychopathologists will be particularly interested in the implications of the present thesis as they may relate to the neurosis and psychosis. The various writers who have dealt with the problem of nervous and mental disease have agreed that the fundamental characteristic in these conditions is the presence of conflict. This conflict may attach to any number of situations. It may express itself in regard to essential circumstances in the patient's life, or to so seemingly trivial a matter as what necktie to put on. It may find any number of symptomatic expressions: the patient may withdraw from the conflict (regression), he may try to solve it on a substitutive level (sublimation), he may deny it in himself and attempt to place it in his environment (projection), he may seek to have others solve it for him (transference), etc., etc. But the important consideration for us at the moment is that conflict is an invariable feature of all conditions of disordered behavior.

Now conflict within a personality presupposes that the personality has been split into parts and that these parts have of themselves acquired an undue independence in relation to the whole personality structure. The central principle within the personality as a whole has lost its coordinating power in respect to partial components. The components themselves have become motivating powers in their own right and hence no unified course of behavior is possible. Psychopathologists have long recognized such a division in the personality of their patients and have named one of the most baffling of psychoses, schizophrenia or split-personality.

As this particular psychosis is one of the topics on which a number of papers will concentrate at these meetings, I should like to mention schizophrenia at least tentatively in indicating the possible bearing of social division and conflict upon psychopathological conditions.

I should indicate at this point that Burrow (8, 9) has emphasized the fact that, concomitantly with the partialization that has inadvertently separated the individuals of the race, there has inevitably occurred a partializing effect within the individual himself. Space does not permit a discussion of this partialization which has occurred within the individual, but perhaps I may say that there is much evidence to indicate that there has been an undue division and restriction in two of the most vital fields of the organism's activity. These fields are those of nutrition and of sex and have to do with the survival of the individual and of the species respectively. In these two physiologically, biologically, psychologically and sociologically primary fields of activation and response, the weight of evidence seems to indicate that the integrity of the reaction of man's organism as a whole has to a large extent been vicariously supplanted by partial reaction tendencies.

We have already considered the fact that from the viewpoint of biological data there is much evidence to support the thesis that man, with his present mental convictions in regard to the independence and supremacy of the element (the individual) in relation to the whole (the race or species), represents an evolutionary anomaly of development. We have seen indications that such a position is not in harmony with biological data, and that evolution could hardly have proceeded at all if lower forms of life had assumed this arbitrary attitude. We have found much

evidence that cooperation is a fundamental property of protoplasm itself and have seen examples of its effectiveness throughout the animal scale. We saw that it was very difficult for the child to delimit his personality, that one of the most difficult concepts for him to acquire in early life was that of being an individual "self," separate and distinct from others. Accompanying the artificial separation of the individual from the race or species, there has been a cleavage in the various physiological systems in relation to the organism as a whole (digestive, reproductive) so that they no longer work in harmonious interfunctioning. At the same time we have seen that there has been a cleavage in behavioral trends, so that conflict, indecision, and their compensatory mechanisms, are rather characteristic of the so-called normal personality.

In the schizophrenic personality, this cleavage in behavioral trends has advanced to such a stage that coordinated activity is precluded, and the individual is no longer able to get along in his environment. There is at times a rather complete withdrawal of contact with regard to stimuli and reactions relating to situations outside the individual, and a concentration on a fanciful world within. This regression is usually looked upon as an escape from a painful reality which the personality is not strong enough to deal with, and a consequent capitulation to a system of subjective phantasy in which the patient can make of his world what he pleases. Such regressions are thought of as due to a diseased or faulty personality resulting from hereditary weakness, developmental trauma or from a deep-seated habit disorganization. There is evidence, however, for the view that these severe personality disturbances and extreme regressions represent an inability to assimilate

socially prevalent modes of thinking and feeling which from an organismic basis are themselves dissociated and pathological.

We know, of course, that community medical hygiene was a very important factor in eliminating the dread epidemics which before the rise of scientific medicine swept human communities. We have need to recognize that community mental hygiene is no less important in dealing with those behavioral disturbances which fill our asylums to-day and which, in the form of crime, war, religious discord, political and economic inequalities, etc. represent socio-pathological processes which are equally epidemic. But if

mental hygiene is really to be effective, we must envisage it in a more intimate, inclusive, less projective manner. I think we shall find that, along with Burrow, we must come to the practical realization that our own daily, normal processes of interchange are partitive and disordered in a very real sense and that we must thus meet the vital social challenge of replacing our partial, ego-centric views, responses and habituations with principles and behavior that are more in line with man's fundamental phylo-biological motivation.

Paper read, by invitation, at the Twenty-Ninth Annual Meeting of the American Psychopathological Association, Atlantic City, June 5, 1939.

LIST OF LITERATURE

- (1) ALLEE, W. C. *Animal Aggregations: A Study in General Sociology.* Chicago (University of Chicago Press), 1931.
- (2) BENEDICT, R. F. *Patterns of Culture.* Boston and New York (Houghton Mifflin), 1934.
- (3) BERTALANFFY, LUDWIG VON. *Modern Theories of Development. An Introduction to Theoretical Biology.* (Oxford University Press), 1933.
- (4) BÜHLER, C. *Die ersten sozialen Verhaltensweisen des Kindes. In: Soziologische und psychologische Studien über das erste Lebensjahr. (Quell. u. Stud. z. Jugendk., No. 5) Jena (Fischer), 1927.*
- (5) —. Spontaneous reactions of children in the first two years. *Proc. and Papers 9th Int. Cong. Psychol.*, 1929, pp. 99-100.
- (6) BURROW, TRIGANT. The psychiatrist and the community. *The Journal of the American Medical Association*, 1914, Vol. 62, pp. 1876-78.
- (7) —. The Social Basis of Consciousness. A Study in Organic Psychology. International Library of Psychology, Philosophy and Scientific Method. London (Kegan Paul, Trench, Trubner and Co.), New York (Harcourt, Brace and Co.), 1927, pp. 256.
- (8) —. The Structure of Insanity. A Study in Phylopathology. Psyche Miniature Series, London (Kegan Paul, Trench, Trubner and Co.), 1932, pp. 80.
- (9) —. The Biology of Human Conflict. An Anatomy of Behavior Individual and Social. New York and London (The Macmillan Co.), 1937, 435 pp.
- (10) CHILD, C. M. Biological foundations of social integration. *Publications of the American Sociological Society*, Vol. 22, The Relation of the Individual to the Community, 1928, pp. 26-42.
- (11) CLEMENTE, FREDERICK E. Social origins and processes among plants. Chapter from *Handbook of Social Psychology*, Edited by Carl Murchison. Worcester, Mass. (Clark University Press), 1935, pp. 22-48.
- (12) COOHILL, G. E. The genetic interrelation of instinctive behavior and reflexes. *Psychol. Review*, vol. 37, No. 3, May, 1930, pp. 264-266.
- (13) —. The structural basis of integration of behavior. *Proceedings of the National Academy of Sciences*, vol. 16, No. 10, 1930, pp. 637-643.
- (14) —. The neuro-embryologic study of behavior: Principles, perspective and aim. *Science*, vol. 78, 1933, pp. 131-138.
- (15) CROOK, BILLIE L. The posture of the young child. *J. Assoc. Childhood Educ.*, vol. 13, 1937, pp. 317-321.
- (16) FRANK, ALMA. A study in infant development. *Child Development*, vol. 9, No. 1, 1938, pp. 9-25.
- (17) GOLDSTEIN, KURT. Der Aufbau des Organismus. Einführung in die Biologie unter besonderer Berücksichtigung der Erfahrungen am kranken Menschen. *The Hague* (Martinus Nijhoff), 1934.
- (18) HEARD, GERALD. *The Ascent of Humanity. An Essay on the Evolution of Civilization.* New York (Harcourt, Brace and Co.), 1929, p. 60.

- (19) KOFFKA, KURT. The Growth of the Mind. An Introduction to Child-Psychology. International Library of Psychology, Philosophy and Scientific Method. *New York* (Harcourt, Brace and Co.), 1931, pp. 427.
- (20) KÖHLER, WOLFGANG. Gestalt Psychology. *New York* (Horace Liveright), 1929, pp. 400.
- (21) KROPOTKIN, P. Mutual Aid. A Factor of Evolution. *New York* (Alfred A. Knopf), 1921, pp. 240.
- (22) LEWIN, KURT. Environmental Forces. Chapter from Handbook of Child Psychology, Edited by Carl Murchison. *Worcester, Mass.* (Clark University Press), 1933, pp. 590-625.
- (23) LASHLEY, KARL S. Brain Mechanisms and Intelligence; a Quantitative Study of Injuries to the Brain. *Chicago* (The University of Chicago Press), 1929.
- (24) MEAD, MARGARET. Coming of Age in Samoa. *New York* (William Morrow and Co.), 1928, pp. 297.
- (25) —. Growing up in New Guinea. *New York* (William Morrow and Co.), pp. 372.
- (26) MELVILLE, HERMAN. Typee: A Real Romance of the South Sea. *Boston* (The St. Botolph Society), 1892, pp. 389.
- (27) MINKOWSKI, M. Neurobiologische Studien am menschlichen Foetus. In: Handbuch der biologischen Arbeiten, part 5, 1928, p. 511.
- (28) MORGAN, C. LLOYD. Emergent Evolution. *New York* (Henry Holt and Co.), 1928, pp. 313.
- (29) MURPHY, GARDNER, and LOIS BARCLAY. Experimental Social Psychology. *New York* (Harper and Brothers), 1931.
- (30) MURPHY, LOIS BARCLAY. Social Behavior and Child Personality. *New York* (Columbia University Press), 1937, pp. 344.
- (31) PIAGETT, J. The Child's Conception of the World. *New York*: Harcourt, Brace and Co., *London* (Kegan Paul, Trench, Trubner and Co.), 1929, pp. 397.
- (32) RIVERS, W. H. R. Instinct and the Unconscious. *Cambridge* (University Press), 1920.
- (33) SPERMANN, HANS. Organizers in animal development. *Proceedings of the Royal Society of London*, Series B, 102: 1927-28, pp. 177-187.
- (34) VIGOTSKY, L. S. Thought and speech. *Psychiatry*, vol. 2, No. 1, 1939, pp. 29-54.
- (35) WERTHEIMER, MAX. Drei Abhandlungen zur Gestalt-theorie. *Erlangen* (Verlag der Philosophischen Akademie), 1925, pp. 184.
- (36) WHEELER, R. H. The Science of Psychology. *New York* (Crowell and Co.), 1929, pp. 556.
- (37) WHEELER, W. M. Social Life among the Insects. *New York* (Harcourt, Brace, and Co.), 1923.
- (38) —. Societal Evolution. In *Human Biology and Racial Welfare*. Ed. by E. V. Cowdry. *New York* (Hoeber), 1930, pp. 139-155.
- (39) WOODGER, J. H. Biological Principles: A Critical Study. International Library of Psychology, Philosophy and Scientific Method. *New York* (Harcourt, Brace and Co.), 1929, pp. 498.





MAN: A CONSTITUTIONAL INVESTIGATION (*Concluded*)

By WILLIAM B. TUCKER AND WILLIAM A. LESSA

Departments of Medicine and Anthropology, University of Chicago

IV. THE METHODOLOGY OF CONSTITUTIONAL INVESTIGATION

A BRIEF consideration should be given to the methods and techniques by which investigators have dealt scientifically with the various aspects of constitution. In general, one may distinguish between the *techniques* of study (i.e. the tools used), and the *methods of approach, or classification*, employed for the better understanding of relationships.

A. *Morphological*

1. *Techniques*

Morphological techniques employed have been observational judgments and measurements. Standard anthropometric measurements are best used, as classically described and defined by Martin (188). In the work of recent years of many authors an important aid to accurate evaluation of the morphology of an individual has been the employment of scientific photography. Usually the individual studied is photographed, preferably nude, at a standard fixed distance from the camera (with a long-focus lens) in three views, front, back, and profile. Sometimes additional closer views are taken of the head alone. This subject has been discussed by Pearl, Sutton, Howard, and Rioch (225).

2. *Methods of approach*

Evaluations of the variations of human morphology may fall into three general categories: somascope, somametric, and scopometric (a term suggested by Cabot (47)).

a. *Somascope*

The term "somascope" or "anthroposcopic" has been applied to purely observational classifications of morphologic types. Popular conceptions rest on unorganized groupings of this kind. Since it is so subjective and hard to handle statistically, it was not until di Giovanni introduced anthropometry into the determination of physical types that one could say that the scientific study of constitutional types had begun. Though the ideal would be to put correlations of mind and body on a single rational basis, this is not quite possible at the present time and subjective observation must remain as the subsidiary tool of the researcher, frequently pointing the way to further research. That the somascope method can rise to great heights is illustrated by Thomas Addison's classic description of pernicious anemia (2). At the time, eighty years ago, when he described the form, skin and subcutaneous tissue of persons with the disease, it was believed he was describing effects. But it is now felt that Addison was really describing, except for the pallor, not the results of the disease, but rather a constitutional type which predisposes the individual to it.

The Frenchmen Sigaud (277), MacAuliffe (185) and Thoëris (301) have utilized the somascope method to a considerable extent. Their form types, the *Respiratoire*, *Digestif*, *Musculaire*, and *Cérébral*, were inspired by a somewhat similar classification made in 1821 by de Troisième (67), a pupil of Halle. According

to Sigaud (277), the *muscular* type has a strongly developed musculature, round head, broad shoulders and large chest; the *digestive* type has a small nose, which is depressed at the base, a large mouth, broad lower jaw, and large abdomen; the *respiratory* type has a broad nose and large chest; and the *cerebral* type has a large head, narrow shoulders and chest, and long narrow fingers.

When Kretschmer (158, pp. 9-10) described his method for studying constitution and psychoses, he began by decrying the isolated observations of medical practitioners of the past, and the belletristic observations of a physiognomical nature. He stresses the need for exact science. Yet his method must be placed in the category of somascope methods because his data, though fairly thorough, include few measurements (and no indices.)

Everything depends on a complete, artistic, and sure schooling of our eyes, for a scholarly list of single measurements without any idea or intuition of the general structure will not bring us much further. The tape measure sees nothing; it never leads us to a grasp of the biological types which are our object.

To many such a credo is rank heresy, yet it was by such methods that Kretschmer was able to indicate much which calipers merely verified. Indeed, he regarded anthropometric measurements as merely more exact formulations of what could be ascertained from scientific observation.

Mayer-Gross (193), influenced by Kretschmer, expresses a total distrust of the exact methods of anthropometry for ascertaining morphological types in psychiatry, but he fails to understand that physiognomic expression is one thing and measurable morphology another.

b. Somametric

Recognizing the advantage to the scientific study of body types that is obtained

with metric methods, many investigators have now adopted techniques which employ measurements and indices solely. These may be termed "somametric" or anthropometric. As early as 1654 Elsholzius (77) at the University of Padua had devised an anthropometric technique to be used in the clinic. Curiously enough after two centuries had passed another professor of medicine in the same university adopted modern anthropometric techniques, for di Giovanni (68) may be considered to have really introduced clinical anthropometry.

For purposes of discussion, somametric techniques may be divided into those stressing either measurements or indices. Absolute measurements rarely or never are satisfactory in themselves, and it is one of the weaknesses of Kretschmer's work that when he did depart from somascope methods he utilized measurements without indices. For absolute dimensions can never adequately express proportions.

Indices themselves are of two kinds, depending on the use to which they are put—to express relative proportions of physical features or to express in themselves the whole morphological make-up. Anthropologists are responsible chiefly for the development of the former type of index. Indices of this type can, if of sufficient variety and number, combine to give a very accurate description of an individual or a group. They have been put to great use, being employed extensively by Draper (69, 71) in describing his disease types.

In order to simplify the handling of statistical data on morphological types, to avoid the subjective factor in judgment, and to arrive at a clear definition of categories, various indices of constitution have been devised. Some of the best known are listed in Table 1.

TABLE 1
Selected constitutional indices

1. Andreev (modified by Westphal and Strauss) (330, p. 247):	$\frac{(\text{chest circ.} + \text{abd. circ.}) - (\text{arm l.} + \text{leg l.})}{\text{transv. chest diam.} \times \text{sag. chest diam.}} \times 100$
2. Bornhardt (39, p. 108):	$\frac{\text{stature} \times \text{chest circ.}}{\text{weight}}$
3. Bouchard (299, p. 484):	$\frac{\text{weight}}{\text{height}} \text{ or } \frac{\text{weight}}{\text{height}} \times 100$
4. Brugsch (43, p. 47):	$\frac{\text{chest circ.}}{\text{stature}} \times 100$
5. Buffon (2174, p. 51):	$\frac{\text{weight (gm.)}}{\text{stature (cm.)}^3} \times 100$
6. Davenport (62, p. 26):	$\frac{\text{weight (lbs.)}}{\text{stature}^3 \text{ (in.)}} \times 1000 \text{ or } \frac{\text{weight (gms.)}}{\text{stature}^3 \text{ (cm.)}}$
7. Florschütz (189, p. 620):	$\frac{\text{stature}}{2 \text{ abd. circ.} - \text{stature}}$
8. Klineberg-Asch-Block (152, p. 172):	$\frac{\text{sitting height} \times \text{weight}}{\text{stature}^3}$
9. Kretschmer (41, p. 233):	$\frac{\text{shoulder br.}}{\text{chest circ.}} \times 100$
10. Kühnel (165, p. 543):	$\frac{\text{transv. chest diam.} \times \text{sag. chest diam.} \times \text{ant. trunk ht.}}{100}$
11. Lenhoff (189, p. 620):	$\frac{\text{ant. trunk height}}{\text{abd. circ.}} \times 100$
12. Livi (176, p. 130):	$\frac{\sqrt[3]{\text{weight}}}{\text{stature}} \times 100$
13. Lucas-Pryor (181, p. 1129):	$\frac{\text{bi-iliac br.}}{\text{stature}} \times 1000$
14. Manouvrier (187, p. 64):	$\frac{(\text{femur l.} + \text{tibia l.})}{\text{trunk length}} \times 100$
15. Marburg "A" (modified by Westphal and Hartner) (329, p. 424):	$\frac{\text{head ht.} \times \text{hand br.} \times \text{shldr. br.} \times \text{chest circ.}}{1000}$
16. Marburg "B" (modified by Westphal and Strauss) (330, p. 245):	$\frac{\text{leg length} \times 10,000}{\text{transv. chest diam.} \times \text{sag. chest diam.} \times \text{ant. trunk ht.} \times \text{shldr. br.}}$
17. Marburg "C" (modified by Westphal and Strauss) (330, p. 246):	$\frac{\text{transv. chest diam.} \times \text{sag. chest diam.} \times \text{biacromial breadth}}{\text{bi-iliac crest br.} + \text{bitrochanteric breadth}}$
18. Martin (188, p. 174):	$\frac{\text{bicristal br.}}{\text{shoulder br.}} \text{ and } \frac{\text{bitrochanteric br.}}{\text{shoulder br.}}$
19. Martinet (123, p. 688):	$\frac{\text{stature}}{\text{stature/transv. chest diam.}}$
20. Mohr-Gundlach (200, p. 127):	$\frac{\text{chest circ.} + \text{abd. circ.} + \text{hip circ.} + \text{weight}}{\text{stature}}$
21. Pearl (221, p. 684):	$\text{cylindrical body vol.} = 0.07958 (\text{chest circ.})^3 \times \text{stature}$
22. Pignet (235, p. 373):	$\text{stature (cm.)} - [\text{chest circ. (cm.)} + \text{weight (Kg.)}]$
23. Pignet-Ver Vaecq (299, p. 497):	$\frac{\text{weight} + \text{chest circ.}}{\text{stature}} \times 100$
24. Plattner (236, pp. 382-383):	$\frac{\text{transv. chest diam.} \times \text{sag. chest diam.} \times \text{ant. trunk ht.}}{\text{stature}^3} \times 1000$

TABLE 1—*Continued*

25. Quetelet (188, p. 175):	weight/stature
26. Quetelet-Gould-Kaup (146, p. 204):	weight/stature ^a
27. Rohrer (248, p. 851):	$\frac{\text{weight}}{\text{stature} \times \text{shoulder breadth} \times \text{thoracic depth}} \times 100$
28. Stockholm (S ₁) (332, pp. 672-681):	$\frac{\text{sternal height}}{\text{transv. chest diam.} + \text{sag. chest diam.} + \text{shldr. br.}} \times 100$
29. Viola (55, p. 33):	Trunk Index/Limbs Index
$\text{Trunk Index} = (\text{transv. chest diam.} \times \text{sag. chest diam.} \times \text{sternal length}) \div (\text{transv. hypochondriac diam.} \times \text{ant.-post. hypochondriac diam.} \times \text{xiphoid-epigastric length}) + (\text{bi-iliac diam.} \times \text{ant.-post. hypochondriac diam.} \times \text{pubic-epigastric length}).$	
$\text{Limbs Index} = \text{arm length to wrist} + \text{leg length to malleolus}$	
30. von Rohden (299, p. 498):	$\frac{\text{symphysis height}}{\text{chest circ.} \times \text{ant. trunk ht.}} \times 100$
31. Wertheimer-Hesketh (327, p. 41):	$\frac{\text{leg length} \times 1000}{\text{transv. chest diam.} \times \text{sag. chest diam.} \times \text{trunk ht.}} \times 100$
32. Wigert (332, pp. 667-684):	$\frac{\text{shoulder breadth}}{\text{transv. chest diam.} + \text{sag. chest diam.}} \times 100$
33. Wigert (332, pp. 667-684):	$\frac{\text{bicristal br.} + \text{bitrochanteric br.}}{\text{shoulder breadth}} \times 100$

Some of these indices have been employed by themselves to express constitution. However, it has been seen that it is not adequate, or it is not possible, to attempt a single criterion of constitution. It must be remembered that constitution is a pattern made up of many constituent parts, and the single index fails to express this.

Ciocco (55) has subjected constitutional indices to careful criticism and warns against putting too much faith in them. He sets down as the requirements of a good index that it must be simple, clear and significant. But in addition it must be definitely correlated with (1) the external morphologic conformation and (2) the internal anatomic structure. An index such as weight/height tells little regarding the first, for while it is true that weight is highly correlated with the horizontal dimensions and stature with the vertical ones, this index is of little use in going outside the limits of the intermediate euplastic habitus. Indices also usually fail to meet the second re-

quirement—the expression of anatomical relationship and variations. For instance, the chest girth/stature index may be the same for two individuals because the actual measurements may be the same, yet one may have a normally flat chest and the other an emphysematous chest. Moreover, an index does not express the relative values to be given to the adipose and muscular development, which may differ in individuals of the same skeletal habitus. McCloy (195, 196) has given these difficulties very careful consideration.

Benedetti (25) expresses dissatisfaction with all indices except Viola's trunk index/limbs index.

Hauchmann (123), in making an evaluation of indices, calculated the degree of correlation between the body build as determined by somascopic techniques and the results obtained through the application of indices. He found that Pignet's index (see Table 1) came closest to expressing morphological structure ($r = -0.76$). Ciocco (55) insists that it is

nevertheless impossible to give a rational statement of the precise physical meaning of a particular value of the Pignet index, whereas Benedetti (25) raises the suspicion that Hauchmann may have made false correlations in obtaining his results.

Implied in most work with single indices is the assumption that there is an ideal average. This is an untenable supposition. It is probably impossible to define accurately the "normal type," which is not to be confused with the "average" or the "ideal." Just as the average of many measurements is no indication of normality, neither is the average of several indices.

In conclusion, while biometric figures are useful guides, one cannot, as Petersen (230) expresses it, "make a constitutional classification solely on the basis of mathematics." The whole nature of constitution would be misunderstood without a realization of the fact that an index cannot fully express the interrelated nature of constitution—a sort of spider web with many constituent parts.

c. Scopometric

Midway between such extremists as Török, a Hungarian who took five thousand measurements on the skull alone, and Sergi (269), who once proposed that measurements be entirely done away with and only observations used, lie the majority of modern students of body build. Their method may be called "scopometric," or a combination of somasopic and somametric techniques. Racial anthropology has found it extremely valuable to employ careful observations along with measurements; even though its objectives are different from those of constitutional studies—one may not properly speak of "disease races"—this conjunction of techniques has its applicability in constitutional investigation.

It is to be noted that when scopometric diagnosis is employed investigators place relatively less reliance on data procured by observations. For example, although Hooton (134) utilizes a few dozen types of observation in describing the 17,000 subjects of his criminal study, he uses indices alone in his analysis of body build.

3. Methods of classification

Aside from the techniques of gathering data there is the important problem of how the material shall be handled for classifying the various types of habitus. It will be instructive to observe the manner in which various investigators have tried to establish categories of body build, especially when dealing with the relation of morphology to disease.

Some have created more or less arbitrary somatic types and then have cast about to see what diseases seem to characterize them. This method has been employed by Viola (309) (megalosplanchnic and microsplanchnic types), Sigaud (277) (respiratory, muscular, cerebral, and digestive types) and Kretschmer (158) (asthenic, athletic, pyknic, and dysplastic types). It is to the advantage of this method that it utilizes but a few categories and is easily applicable in the clinic. However, few individuals fit such categories perfectly, for the great mass of people are not well differentiated and are usually found to be intermediate. From earliest times men have been disposed to favor this manner of classification, but its advantage of simplicity has been vitiated by the difficulty of handling it statistically. A similar tendency to simplify, with bipartite classifications, is seen in the physiological differentiation between vagotonia and sympatheticotonia, and the psychological differentiation between schizothymia and cyclothymia, between schizophrenia and the cyclic psychoses.

Some justification for this type of division is apparent in the tabulation of data. If all individuals were geometrically alike, then body weight would vary directly as the cube of height, for height is a linear dimension and weight, or mass, a cubic one. When actual height-weight tables are examined this is seen not to be so. Such a table has been prepared by Kaup (146, p. 218) in *Biologie der Person* (44, I.), and it can readily be seen here that there is a discrepancy between the actual weights and the theoretical ones (cf. Table 2). Such figures demonstrate that human beings are not free to vary in all directions; as the result of such a limitation the average short man must be re-

is also suggested that perhaps when an individual has one characteristic which deviates from the average, other characteristics in the germ plasm may be linked with this and cause a greater deviation.

Another philosophic form of speculation, from an evolutionary point of view more broad and more vague than the ontogenetic or even the phylo-genetic, may be worth considering briefly. Life in its simplest form, as now known, probably originated as a cell nearly spherical in form, with the greatest conservation of mass to surface area. This probably served for protection of the individual when motion was not as necessary as self-preservation. But

TABLE 2
Comparison of actual and theoretical weights

AUTHORITY	LENGTH CLASSES			PERCENTAGE DIFFERENCE 11.5%
	160 cms.	170 cms.	180 cms.	
Schweinig.....	60.2 kg.	66.6 kg.	74.3 kg.	23.4%
Brugsch.....	59.3 kg.		71.0 kg.	20.0%
Rautmann.....	58.3 kg.		71.9 kg.	23.0%
Theoretical Weight.....	60.0 kg.	70.0 kg.	85.4 kg.	40.0%

garded as a different geometrical type from the average tall man. (See also section II. E. 3 for other discussion of height-weight relationships.)

How can such a limitation be explained? One could speculate that far back in human history there were two distinct geometric types of races and that in the mixture of these ancient stocks clean cut types have been lost, but sometimes tend to reappear. Or one might maintain that a process of natural selection is at work—individuals who are tall must find it a great advantage to have a body-surface/weight ratio below the theoretical normal, for heat is lost from the surface and the greater the surface the higher must be the metabolism. The possibility

there probably came a period when motility was of greater importance. While a sphere can roll, in doing so it is at the mercy of its environment; to exercise greater control of such motility an evolution of form must take place. Very possibly the hypothetical primordial biological sphere became roughly ellipsoid, cylindrical, or even developed rectangular or block-like projections. So may have been introduced primary elements of greater ruggedness, possible *anlage* of systems of locomotion. If such an evolutionary trend is carried farther, mass shrinks rapidly in proportion to linearity, and, carried to a logical but extreme conclusion, one might expect some form approaching a pole or a rod,

or even an hypothetical straight line, having only one dimension—but survival value would be lost somewhere along such an evolutionary road.

Perhaps it is not too fantastic to draw parallels between such hypothetical primitive forms and different kinds, sizes, and shapes of man himself. Man must locomote, and has extremities for this purpose. Man's head protrudes, too, the better to enable him to control his environment. Aside from extremities and head, however, he may be considered roughly cylindrical in form. The cylinders of some individuals definitely approach the sphere in shape; in others a blocky cylinder or rectangle or block; and in still others go a long way toward the lack of sufficient material substance to maintain life. It is small wonder that these latter, the leptosomes or asthenics, have been called by some the "hyperevolute."

But such philosophic speculations and explanations are idle and without scientific value, and are offered here as no more than food for thought.

Another method of morphological classification, quite as arbitrary as the one already discussed, bases its categories on extreme types of habitus—dysendocrine types, progeria, the diatheses, status lymphaticus, and various pathological groups. The method is satisfactory within its obvious limits: it has applicability only for extreme types. Moreover, the groups so formed are not equally pure; and there is no discrimination between those with disease and no disease. The technique does, however, give some good leads, for it shows that within the general population many individuals do belong to such extreme types who otherwise would not be well differentiated. (It is true that some of these types always appear in relatively pure form, e.g.

mongolian idiots.) Little is known of the nature or origin of such types.

There is still another method of classification, that of the physical anthropologist. In combining the two above methods it has proven more satisfactory than either. Data is gathered on a group of individuals who, it is suspected, correlate with the category under investigation, and this group is compared with another similarly treated to determine if there is a significant difference. In this way anthropologists have been able to establish descriptions of races, growth changes, sex differences, etc. This method, for example, has been used by Draper. Data secured on patients is separated according to disease groups and the classifications so created compared with one another in order to see if significant differences are apparent. A variant on this technique is to gather data on as large a group as is pertinent to the study, segregate those individuals which tend to cluster about certain types, and then determine if such types correlate with whatever category one may be investigating.

Temporarily such methods may have great value. But when valid systems of morphological classification and norms shall have been worked out *for the entire population* it would seem the more logical procedure to compare given groups with such norms, rather than employ inter-group comparisons.

B. Physiological—Techniques and methods

The methodology of investigation in the physiological aspect of constitution is much less well organized than in the morphological. In general the techniques are those developed by the biological scientists, chiefly the biochemists, the physiologists and the clinicians, and the physiological characters studied are fragments of the total individuality without

much systematic classification. These fragments individually are not without their significance but generally they are so minute that the significance of each is hard to discern.

The hope of the future in this field lies in endocrinology, as the Italian school has pointed out. As simpler and more accurate methods for studying endocrine physiology are evolved it may be possible to elaborate a classification of constitutional physiology that will at once be comprehensive, be easily correlatable with both morphology and psychology, and serve as the skeleton onto which to fit the soft parts of the more detailed physiology now studied almost exclusively.

Lacking such a schema at the present time, it is still well to mention the chief methods of evaluating physiological differences. Day (64) has compiled a very complete list. It is unfortunate that this phase of biological investigation has emphasized too exclusively the establishment of standards to the comparative neglect of possible laws governing the variations of individuals from such standards—i.e., statistically speaking, emphasis has been on determining the mean at the expense of the standard deviation.

Pende (228, pp. 65-74), in discussing his study of the "dynamic-humoral criterion" of constitution (his term for the equivalent of the physiological aspect), lists and describes the following useful techniques: basal metabolic rate determinations; determination of the specific dynamic action of food; study of glycemia and carbohydrate tolerance; a physiological anamnesis to determine the stability of the autonomic nervous system; pharmacodynamic tests with epinephrine, pilocarpine, eserine, atropine, histamine, insulin and ergotamine; certain special reflexes as the oculo-cardiac reflex, the pilomotor reflex, and certain pupillary

reflexes; and reactions of the skin to light scratching (dermographia) and to intracutaneous injections of numerous chemicals.

Study of the electrocardiogram and of the spirogram have also been employed, and the detection and study of electric currents in other parts of the body may hold considerable promise.

C. *Pathological—Techniques and methods*

The methodology of the pathological aspect of constitution is that of the clinician and the pathologist, and is so well known as not here to need description. Organization and classification of pathological observations along taxonomic lines is, as in the case of constitutional physiology, somewhat fragmentary and inadequate, although the most careful workers in this field seek constantly to keep the integrated individual, and not simply his pathological parts or organ systems, as the prime consideration. The total list of possible pathological ailments afflicting man today recognized as clinical entities or pathological conditions runs into the thousands, and fills 600 pages of fairly fine print in the *Standard Classified Nomenclature of Disease* (286). Such diagnoses are to be considered the sound basis for the correlative study of pathology in constitution, at the present time.

D. *Psychological—Techniques and Methods*

The methodology used in the recognition of personality types is not to be confused with that of determining morphological types, earlier discussed.

Personality types may be diagnosed in the following ways (47), technologically and methodologically:

(1) The clinical diagnosis of psychoses (e.g., schizophrenia and manic-depressive psychoses).

(2) The diagnosis of personality types by means of autodiagnosis, where the subject answers questions

presented either during the interview or when expected in response to a paper and pencil test.

(3) The diagnosis of personality types by means of observation of behavior.

(4) The diagnosis of personality types by means of a combination of any of the preceding methods.

Most of the work in the field of psychology stems from the two pathologic types of the psychiatrists first delineated by Kraepelin—schizophrenia and the manic-depressive psychoses. Utilizing these clinical categories, Kretschmer (159) came to the conclusion that even normal personalities could be correspondingly dichotomized into schizothymes and cyclothymes, associated respectively with the asthenic and the pyknic habitus, as in the case of the psychoses. Few of the investigations into the psychological aspect of constitution are concerned with anything else than an attempt to verify or discredit Kretschmer. For this reason resulting psychological classifications are intimately interwoven with morphological types, attempting correlations by what has been called "experimental clinical diagnosis." The chief subjects of inquiry along this line have been in the psycho-motor responses, physiological functions, color reactions, psycho-galvanic reflexes, school ability, handwriting, and stuttering.

The chief criticism of the majority of such investigations has been the fact that very seldom has data been accumulated on relatively normal individuals; the subjects have usually been institutional or clinical cases.

Draper (71) has expressed great faith in the psychoanalytic approach to the understanding of the psychological background of the individual, saying that "the methods which have proved most valuable at the Constitution Clinic not only as therapeutic forces but for the purpose of research have been those of free association and the dream."

Intelligence is also studied, and the methodology of the study of this part of the psychological aspect is well known, the Stanford-Binet Test being the standard. Various other tests have been devised to study various intelligences, such as the mechanical aptitude test, the rapid reading test, word association tests, color fusion tests, perception span tests, etc.

V. RESULTS OF RESEARCH

A. Morphology

1. Systems of classification

It is a curious and perhaps significant fact that 2500 years ago Hippocrates (129) said that there are two roots of human beings, the long thins and the short thick. Almost all simple classifications of type since that time have nearly the same basis, despite variety of nomenclature and detail of description. Even in the world of insects has such a distinction been made, especially in the delightful essay by Wheeler on the *Physiognomy of Insects* (331). The slender type of human has been variously called the leptosome, the longitudinal, the linear, the asthenic, and the dolichomorphic; the broad type has been called the plethoric, the apoplectic, the pyknic, the gouty, the *arthritisismus*, the round type, and the brachymorphic. This bi-polar grouping is useful for its simplicity and has been described in detail by Stockard (294, 295). Hackel (117) has summarized the various methods of classification that have been employed. A comparative tabulation of the many systems that have been used is given in Table 3.

Careful inspection of this table is warranted. It is obvious that the various systems represent different, but only slightly different, approaches to the problem of human morphology taxonomy. Some are primarily morphological, others include physiological properties inferen-

TABLE 3. *Classifications of constitutional types*
(Adapted from MacAuliffe (185), Wertheimer and Hesketh (327), Cabot (47), McCloy (195), and Klineberg (151))

SOURCE	NATIONALITY	1	2	3 ^a	3 ^b
Hippocrates (460-400 B.C.)	Greek	Habitus apoplecticus	Habitus phtisicus (long, thin)		
de Haller (1750)	Swiss	Abdominal	Athletic	Thoracic	Nervous, cephalic
Halle (1797)	French	Abdominal	Muscular	Thoracic	Nervous
Cabanis (1802)	French	Digestive	Muscular	Respiratory	Cranial
de Trousseau (1821)	French	Nutritive beauty (Venus)	Locomotive beauty (Diana)		Cerebral
Rostan (1828)	Engl.		Athletic	Asthenic	Mental beauty— (Minerva)
Walker (1832)					Cerebral
Carus (1833)	German	Phlegmatic (Plethoric venous)			
di Giovanni (1877)	Ital.	Third combination	Second combination (Plethoric)	First combination (Phtisic)	
Beneke (1878)	German	Rachitic	Carcinomatous	Scrofulous, phtisical	
Beneke-Kolditsky (1878)	German	Hyperplastic	Normal	Hypoplastic	
Huter (1886)	German	Ernährungstypus	Krafttypus	Empfindungstypus	
Manouvrier (1902)	French	Brachyskeletal (Micro-skeletal)	Mesoskeletal	Macroskeletal	
Stratz (1904)	German	Xanodermic (Racial)	Leucodermic (Racial)	Melanodermic (Racial)	
Virenius (1904)	Russ.	Connective	Muscular	Epithelial	Nervous
Schiller (1907)	German	Digestive	Hypertonic, apoplectic	Atonic, Asthenic	
Sigaud (1908)	French	Hypo-onto-morph	Muscular	Respiratory	Cerebral
Bean (1912)	Amer.	(Hypo-phylo-morph)	Meso-onto-morph	Hyper-onto-morph (Hyper-phylo-morph)	
Tandler (1913)	German	Herbivorous	Hypertonic	Hypotonic	
Bryant (1915)	Amer.	Hypersthenic	Mesoplastic (Normal)	Carnivorous	
Goldthwaite (1915)	Amer.	Hypersthenic	Mesoplastic (Normal)	Carnivorous	
Mills (1917)	Amer.	Wide chested	Sclenic	Asthenic (Hyposthenic)	
Brugsch (1918)	German	Megaloplastic	Normal chested	Narrow chested (Asthmatic)	
Viola (1919)	Ital.	(Macrosplanchnic)	Normosplanchnic	Microsplanchnic	
Davenport (1923)	Amer.	Fleshy biotype	Medium biotype	Slender biotype	
Stockard (1923)	Amer.	Later	Intermediate (Normal)	Linear	
Aschner (1924)	German	Broad	Normal	Slender	
Bauer, J. (1924)	Austr.	Hypersthenic habitus (Arthritic habitus)	Sclenic habitus	Asthenic habitus	
Bonnak (1924)	Russ.	Euryplastic		Stenoplastic	
Draper (1925)	Amer.	Gall-bladder		Ulcer	
Kretschmer (1925)	German	Pyknic	Athletic	Leptosomic (Asthenic)	
MacAuliffe (1925)	French	Round		Flat	
Weidenreich (1926)	German	Eurysome		Leptosomic	
Pende (1927)	Ital.	Hypervegetative		Hypovegetative	
von Kohden (1928)	German	Endodermic	Mesodermic	Ectodermic	
Sheldon (1939)	Amer.	Endomorph (Pykno-trypherosomic)	Mesomorph (Somatosomic)	Ectomorph (Leptosomic)	

* These two classifications are by many authors listed separately, making a total of four or more classifications, but they seem to be only slightly different emphases of the same general type, more properly grouped together.

tially related to morphological variants. Indeed the approaches are so varied that it scarcely seems logical to compare the different schemata, on first glance. As Wertheimer and Hesketh have said (327, p. 9):

... it may appear inappropriate, or even unjust, to chart side by side the classical traditional types of Hippocrates, the romantic-symbolic system of Carus, the esthetic mythological analogies of the English anthropologist Walker, the dogmatic pathological "combinations" of di Giovanni, and the clinical anthropometric findings of Manouvrier, Viola, Brugsch, and Davenport, the brilliant intuitive divisions of Sigaud and his pupils which have been put to clinical use by Julius Bauer, the pathological-anatomical observations of Rokitsansky, Beneke and Kundrat, the anatomical types of Mills and Stockard, and the careful clinical descriptions of the psychiatrist Kretschmer.

The striking conclusion is that despite this diversity of methodology there are certain clearly recognizable and generally agreed upon elementary variations in human morphology. Korányi (155) states, after a careful and thorough review of the major approaches to the methodology of the study of constitution: "... the foregoing attempts to distinguish various types of men, from widely different points of view, lead always to approximately the same results," and concludes deductively that there must be a highly reasonable validity in the major classificatory systems distilled from these men's observations.

It is true that the complexity of the problem baffled some workers. Stockard (295) reduced all variations to a bi-polar distribution, mentioning only briefly the "intermediates" or "normals." This same general schema is also adopted by Manouvrier (187), Bryant (45), J. E. Goldthwait (103), Kugelman (164), and Bean (22). Rautmann (240, 241, 242, 243), too, has studied the inter-relations

of the body in its various parts and has worked out a fairly simple classification.

Such a bipolar oversimplification has a certain statistical validity. If any single criterion is used to differentiate variations from the mean, it is found that individuals fall into a distribution pattern approximating the bell-shaped curve of "normal" distribution. This is well known by all biometricians, and is discussed simply and adequately by Harris (122). McCloy (195, p. 22) points out that whatever index is used to determine body build the result is such a distribution. In the present state of inexactitude and confusion it is perhaps not unnatural that the emphasis should be placed primarily on the two extremes and reference be made to all others as "intermediate," as Pearl and Ciocco (54, 221) have done in their otherwise excellent study of body build in relation to disease.

Some workers have gone so far in this reinterpretation that they seem to have overlooked original definitions and descriptions. Pearl (221), for example, has placed Kretschmer's "athletic type" in a position intermediate between his "leptosome" and his "pyknic," largely on the grounds of statistical necessity. A careful perusal of the descriptions of the "types" of certain authors, however, as of Rostan (251), Sigaud (277), and especially Kretschmer (158) suggests the recognition of a *third major variant*, i.e., a deviation from the mean in a third dimension, in addition to the two most easily recognizable forms, the very linear and the very lateral. This third element is the very stocky and muscular as distinguishable from the "pyknic."

It is true that even Kretschmer, who has among recent writers contributed most to the recognition of this third variant, is confused in his distinctions between

his "athletic" and his "pyknic" types. This general confusion seems to arise from the general failure to observe that at the end of the distribution (according, e.g., to a height-weight relationship criterion) opposite to the slender there are two fundamentally different kinds of "laterals"—the very heavy due to a relatively high degree of development of deposits of fat, and the very heavy due to a relatively high degree of development of the musculo-skeletal elements of the body. Toward the other end of the distribution, there is also confusion between the basic morphological elements of the asthenic and the athletic types. Caroli and Corman (49) examine this confusion carefully and distinguish with considerable success between length *per se* and gracility or slenderness (*grille*), and note Kretschmer's changed terminology in his later writings, in which he replaces the less meaningful term "asthenic" with the more accurate and expressive term "leptosomic" (= delicate-bodied). The same confusion is reflected by McCloy (195, p. 19), who makes the statement that "the linear type in general has a larger musculature proportionate to his vegetative or visceral parts."

Von Rohden (317), in a study of psychoses (see section V. D. 2. b.), uses as his basic morphological classification the trichotomous system of Huter (139), formulated about 1880. This divided people into three groups or types: cerebral (*empfindungstypus*), muscular (*krafttypus*), and digestive (*ernährungstypus*), with ectodermic structures (skin and central nervous system) predominating in the first case, mesodermic structures (chiefly bones and muscles) in the second, and endodermic (digestive apparatus) in the third. This is remarkably similar to Kretschmer's basic classification, and Kretschmer may have been influenced by Huter's descrip-

tions, although he does not refer to him in his book (158). Von Rohden (317) employs this basic classification in his study and finds schizophrenics to be predominantly ectodermic, or leptosomic; epileptics predominantly mesodermic, or athletic; and manic-depressives predominantly endodermic, or pyknic (see section V. D.). This work of von Rohden's seems carefully done and important, except that it seems to give an unusually high percentage of leptosomics (ectodermics) in the "normal" population, and this casts some doubt upon the validity of his classification.

Saltykow (254), employing certain anthropometric measurements, observes five different elements—asthenic, gracile, fibrous, pyknic, adipose—among individuals, and classifies them according to various combinations of these elements.

The clearest description of and distinction between the three almost universally recognized elements or components of the body seems to have been made by Sheldon (274). Sheldon has made three unique contributions to the science of somatology: (1) he has cleared up much of the inaccurate distinctions between basic morphological elements; (2) he has ascertained that *each* element, or component, *exists to some degree* in every individual, on a sliding scale from very low to very high, which he has arbitrarily divided into 7 units, thus avoiding the "type" error; and (3) he has perfected a scopometric technique, combining photography, observation, and anthropometry, which appears to measure degrees of these three components with high accuracy, validity and reliability, based on studies of several thousand "normal" and psychotic individuals.

Sheldon has chosen to consider as the *first* component that element generally identified with and called "digestive" or

"pyknic"; as the *second*, that called the "muscular" or "athletic"; and as the *third*, that called the "leptosomic" or "asthenic"—but with important differences in the recognition of each. It is interesting to note that Sheldon now calls these three components, respectively, *endomorphie*, *mesomorphie*, and *ectomorphie*, terminology strikingly reminiscent of Huter and von Rohden, although Sheldon earlier employed the terms *pyknosomic*, *somatosomic*, and *leptosomic*, respectively. The term *trypherosomic* has also been suggested (Dr. George Gomori, of the University of Chicago Clinics) to denote the first, pyknic, or endomorphic component (Greek: *trypheros* = soft, round, with connotations of femininity, and *soma* = body).

Much of the more recent morphological taxonomy avoids the tendency to bipolarism. The most outstanding work in the anthropology of disease has probably been that of Draper (69, 71). Utilizing anthropometric and anthroposcopic techniques and jaw casts, he describes various disease "races." Draper was careful to state that measurements alone could never express all the subtleties of contour and feature proportions of the human face. For this reason he also recorded impressions.

The groups which he describes in detail are the gastric ulcer, gall bladder, pernicious anemia, nephritis and hypertension, diabetes, acromegaly, acute rheumatic fever, hypertrophy of prostate and pulmonary tuberculosis. Draper is well aware that the individual constitution is a complex organism and does not neglect to tie up morphology with sex, heredity, and psychology. Realizing the importance of serology and physiology, he has recently also begun to study these aspects of constitution in some detail.

2. Applications and criticisms

In an attempt to investigate the functional adequacy of the various types of pelvis, Greulich and Thoms (112) computed the percentage of women of each pelvic type who required some sort of operative intervention during delivery. If proof of the adequacy of a given pelvic type is its ability to function efficiently during parturition, say these writers, then the adequacy of the long oval and the round pelvis is convincingly demonstrated, for the incidence of cesarean section in a series of 600 cases was:

dolichopellic.....	0.0%
mesatipellic.....	0.7%
brachypellic.....	4.3%
platypellic.....	15.4%

The "normal" pelvis is found to be far from the transversely flattened type which the literature of obstetrics and even anthropology has claimed, for the long oval and round pelvis are much more common to all races and social groups. Strangely, women enjoying a better economic level and a superior physical status had a higher percentage of dolichopellic pelvis, a condition which has even been called "anthropoid," but which is actually better adapted for delivery. Greulich and Thoms believe that nutritive and other factors which permit the attainment of maximum normal growth also prevent the undesirable transversely flattened pelvis. It is interesting to note that no association was found between pelvic type and the rest of the body.

Morphology is frequently attacked as a method of approach to constitution by writers who believe it is not important as a deciding factor in the etiology of disease. Feigenbaum and Howat (88) state categorically that "there is little doubt that many attributes of the body which have been said to render a person

displaying them susceptible to a certain disease have actually been produced by disease." They see no connection between physical constitution and three types of disease which they investigated—peptic ulcer, cholecystitis, and diabetes. Using Draper's methods and even arriving at results which agree with his, they nevertheless believe that these results are negative in the light of their own statistical treatment. However, it seems unwarranted for Feigenbaum and Howat to expect to find significant differences on all or any appreciable number of the anthropometric measurements and indices taken. They do make an important contribution in this subject in pointing out the comparative futility of depending solely on anthropometric techniques without integrating and correlating them into a more comprehensive pattern. (For a further discussion and interpretation of their work, see section V. C. 6.)

Hess and Blackberg (127), though expressing faith in the importance of constitution in etiology, conclude that their work in the production of rickets in puppies shows the physical type of the animal is not the deciding factor.

Says Matthew Young (333) after a study of the physical type of a large number of children with asthma and rheumatism, using a third group of normal children as a control:

The differences in the three groups of children, the asthmatic, the rheumatic, and the normal, in respect to the aggregated physical characters brought under review, are relatively so slight that they cannot be considered to support the view that asthmatic and rheumatic children really differ on the average from one another or from the general population of children from which they are drawn in bodily conformation or physical type, though they may possibly, indeed probably, differ in other constitutional traits.

These critics, far from disbelieving in the constitutional factor, believe that

it is necessary to make investigations in other aspects rather than physical constitution. Draper (71, p. 105) himself, who has relied so largely on morphology, has said on the subject: "In itself, the study of human morphology adds perhaps but little; as a means to the larger conception of the man as a whole, however, it is well nigh indispensable."

Aside from investigation of constitutional morphology itself, the rest of research in constitutional studies consists chiefly of the application of morphological techniques and classifications to an investigation of other aspects of the field as a whole. Specifically, it is concerned with studying the correlations between morphology, and physiology, pathology, and psychology, as outlined in the statements of the objectives of constitutional research (see section III). The balance of this paper will be concerned with such interrelationships.

B. Physiological variations related to morphology

As has been stated, the methodology of the investigation of the physiological aspect of constitution has been relatively unsatisfactory,—unsatisfactory in the sense that the work done has not been well integrated and so is less meaningful than it might be.

1. Detailed physiology

But a number of interesting and important investigations have been made relating morphology to physiology. Petersen (230) summarizes many of these in an excellent review, under the following headings:

Blood pressure: the average levels of both systolic and diastolic readings are higher in hypersthénics, and tend to be progressively lower as the body build varies toward the asthenic.

Hematopoietic system: a "greater functional ca-

capacity" is found in the hypersthenics, together with a higher blood count, on the average; the asthenics show a greater tendency to anemia. Petersen quotes Bryant and Liwtschin as finding approximately the same correlations, though with slightly different morphological classifications.

Uric acid: increased in hypersthenics even without disease, and is of course especially elevated in patients with obesity, gout, gall-bladder disease, arteriosclerosis, hypertonia, and bronchial asthma, which diseases Petersen states are all comparatively rare in asthenics.

Ferment balance: catalytic energy of the blood is highest in hypersthenics, lowest in asthenics. That is, hypersthenics show in general higher catalytic and lower diastatic energy than asthenics. Petersen quotes Morew as having confirmed these observations in children.

Bilirubin: asthenics show higher values than do hypersthenics.

Capillary permeability: lower in athletics and hypersthenics.

Skin reactions: superficial dilatation of the capillaries occurs commonly in the pyknics, contraction in the asthenics.

Vasomotor stability: more reaction to epinephrine in asthenics.

General tissue reaction: pyknics exhibit an increased irritability of the tissues to various substances early in life, with resulting greater wear and tear in adult life, and the opposite is the case in asthenics. Petersen believes this may be "a trophic principle sufficient to account for the differences in the reactivity of the two types towards diseases" (p. 295).

Fat metabolism: the lipolytic index is greater in hypersthenics, and they produce, use and store fat to a greater extent than do asthenics; there is increased lipemia and lipolytic energy in the hypersthenics.

Carbohydrate metabolism: diastatic enzymes are low in hypersthenics, and higher in the blood of asthenics. The latter, too, show a greater tendency to hyperglycemia: to the glucose tolerance test they exhibit greater lability, in that the blood sugar rises more sharply and returns to normal more rapidly than is the case with hypersthenics.

Respiration: the vital capacity is proportionately greater in asthenics, and they have a better gaseous exchange.

Petersen and Levinson (231) in 1930 studied a series of "normal" men, and divided them, according to a weight-height ratio, into the more slender and the heavier quartiles, discarding the

intermediate two quartiles, and contrasted a number of physiological variables in the two groups, with the average age the same in the two cases. They tabulate their findings as follows:

PHYSIOLOGICAL REACTIONS	HEAVY GROUP	SLENDER GROUP
Capillaries.....	0.57	0.63
Blood sugar determinations (fasting).	73.8 mgm.	69.5 mgm.
K/Ca ratio.....	2.08	1.81
Threshold of muscular irritability.....	3.48 m.v.	2.38 m.v.
Epinephrine reaction..	+8% incr.	+12% incr.
Cholesterol.....	225 mgm.	210 mgm.
Reaction to Kromayer irradiation.....	2 hours	2.2 hours
Carbon dioxide combining power.....	54.5	58.5

It is obvious that some of these results are probably not significant, especially as no statistical evaluation is presented, but this approach to the problem is nevertheless of interest.

Petersen and Willis (232) also examined the capillary permeability of normal medical students in relation to body build. They found a distinctly lower permeability in individuals of athletic physique than in the group studied as a whole. Brugsch and Lewy (44) found the blood supply in relation to muscular development greater than average, especially in the athletics, and found that if the vascular system was well developed, muscular hypertrophy resulted; if the vascular system was small, no hypertrophy was noted.

Tschernorutsky (306) found a distinct correlation between cholesterolemia and body build, with lower figures in the asthenics, thus in general confirming the figures of Petersen and Levinson given above. Petersen (230) likewise quotes Miasnikow as having obtained the following figures for cholesterol in the blood: 1.8 per cent for hypersthenics, 1.3 per

cent for asthenics, increasing with age in both groups, but maintaining the same differential for each age group.

Gildea, Kahn, and Man (102), in an extremely well done study of certain biochemical-morphological relationships in normal students at Yale, separated the extreme pyknics and the extreme leptosomes, much as Petersen and Levinson did, and found consistently higher figures for serum lipoids in the pyknics than in the asthenics, the average difference being 8.7 times the probable error of the difference for men and 2.5 for the women.

Ortfried Müller (204) noted differences in the skin capillaries of pyknics and asthenics, observing that the pyknics in general had large capillary venous dilatations, as for example, over the nose and cheeks, wide capillaries in the upper chest, venectasia in the pelvic region, and, generally speaking, a capillary bed of the extremities showing less change, than in the asthenics. In the asthenics he noted evidences of a tense neuro-vascular mechanism, as a pseudo-anemic pallor of the face, and bluish, clammy hands with dilated subpapillary venous plexuses.

Katase (144) states his belief that the acid-base balance of the diet has something to do with the body build of an individual. He infers this from animal experiments in which he found that young animals fed on alkaline diets show a relatively broad development as compared with their controls, and animals fed an acid-forming diet exhibit a relatively longitudinal development. Petersen lends some validity to this novel argument when he notes (230, p. 295) that "typically pyknic individuals apparently have a tendency to retain basic valencies as contrasted to the leptosome."

Borchardt (37), in addition to his studies on the relation of heredity to disease (section II. D. 4.), has called attention

to the importance of the term introduced by Ueber, "histiogenic retention," believing that this deserves broad application in understanding the different physiological qualities of the pyknics and the asthenics. Brugsch (42) employs the same concept when he speaks of the "lipogenic tendency of the tissue" of pyknics. Borchardt goes further in this regard, and states that because of a greater "histiogenic retention" in pyknics, they have better conditions of insulation and lower metabolic requirements, thus explaining his observations that the basal metabolic rate is definitely lower, on the average, in pyknics and higher in the asthenics. J. Bauer (16) likewise speaks of a "lipophilia" in pyknics.

2. Basal metabolism

Lucas and Pryor (181, 182, 183) have also studied basal metabolism with respect to the body build factor, in a very thorough investigation on normal San Francisco children, using chiefly width-length indices as their criteria of body build. On the basis of a very careful and entirely valid statistical analysis of their data they are able to conclude (182) that,

normal slender-built children normally have higher basal rates than broad-built children of the same age-sex group. High basal metabolic rates as measured by the conventional standards are the rule for the linears whose width/length indices are well below average.

In the slender-built group not only did they find the basal metabolic rate higher, but also the total calories per hour, the calories per kilogram body weight per hour, and the calories per square meter body surface per hour. They conclude that insofar as the width/height index measures constitution, the constitutional factor is to some appreciable extent causative of differences in basal metabolism.

3. Electrocardiograms

As a rather different approach to the study of the "physiological panel" of constitution, Draper, Bruenn and Dupertuis (74) have made a careful study of electrocardiographic patterns. They find a "high degree of constancy over a long period of time in the individual electrocardiographic pattern," and proceed then to examine the possibility of using this in the study of individual constitution. Working with gall-bladder and ulcer patients predominantly, they found the following differences:

<i>Gall-bladder</i>	<i>Ulcer</i>
P-R interval longer (especially in 3rd-4th decades)	P-R interval shorter
Q-T interval shorter	Q-T interval extremely long
	Sinus arrhythmias commoner than in normals, especially in 3rd-4th decades
Pulse rate slower than normal	Same, especially in 6th decade
Curve smoother, more rolling	Curve steeper, more abrupt

Their interpretative comment is: "The marked prolongation of the P-R interval, like sinus arrhythmia and a slow pulse rate, expresses a strong vagus influence . . . possibly indicating the peculiar vagotonicity of the ulcer patient." When it is recalled that the ulcer patient is predominantly linear and the gall-bladder patient predominantly lateral in body build (see section V. C. 6.), the above differences may have even further significance. Draper and his associate Coy are at the present time working still further on the problem of electrocardiographic patterns as tools in differentiating physiological variables of constitution.

Little yet is known definitely of the differential physiology of the endocrines with respect to its correlation with body-

build. This must await simpler and more adequate techniques of assay than are now available, but promises much for the future. Lacking such data, however, it is yet possible to note certain significant physiological correlations with different morphological patterns. The basal metabolism findings of Lucas and Pryor are particularly important. The suggestion of a higher histiogenic or lipogenic retention in the pyknics must be investigated further. There is much hope in the future of studies along these physiological lines as better correlational techniques will be worked out.

C. Relation of morphology to pathology

1. General considerations

Observations of apparent preponderance of disease with regard to certain rough variations in body build have been numerous. In recent years many of these have been quite well substantiated statistically. For example life insurance records from Trieste, 1926 (Jackson, 141, p. 122), give us the information in Table 4. Jackson states figures in America, Germany, and other countries are in essential agreement with these. Such figures deal only with causes of death, and not all illness, and do not distinguish between bodily habitus resulting from disease or possibly contributing to it. But such correlations, based on mass figures, are not without their value. It is interesting to observe that they seem to confirm the validity of Hippocrates' observations with regard to the "habitus phthisicus" and the "habitus apoplecticus."

Freeman (92) has made a careful study of the relationship between body build and various diseases. He summarizes his findings for 1260 cases, eliminating diagnoses considered less important when more than one was found to exist in a given individual, in Table 5.

From the figures obtained, Freeman finds a relatively high proportion of asthenics among the tuberculous, of pyknics suffering hemorrhagic pancreatitis, of athletics with intestinal disorders. He summarizes (p. 808):

A few other disorders in which the special body type contains more than 40% of the total may be mentioned. Cardiac valvular disease, aortic aneurysm, cerebral thrombosis and hemorrhage, nephritis, pyelonephritis, prostatic hypertrophy and malignancy, pituitary tumors, goiter, and subdural hematomas, occur in considerable numbers in the athletic type. Pulmonary abscess and gangrene as well as pulmonary and intestinal tuberculosis pick out espe-

Freeman's final perspective on this problem is given as follows:

... certain constellations may be picked out as contrasting examples of human biotypes. The asthenic-tuberculous-schizoid contrasts with the pyknic-angiopathic-cycloid, and both of them with the dysplastic-exudative-epileptoid, while another less striking example is the athletic-paranoid group showing decided tendencies toward malignant disease and chronic streptococcus infections.

Criticisms of all such sets of figures, whether totals from life insurance records, or more careful studies of pathological material, will be unavoidable. Grounds

TABLE 4
Body build related to mortality

CAUSE OF DEATH	PHYSIQUE		
	This (Percent)	Medium (Percent)	Scout (Percent)
Tuberculosis.....	25.7	13.1	4.1
Apoplexy.....	4.9	9.2	12.3
Circulatory disturbances....	9.4	14.8	22.7
Pneumonia.....	11.7	10.3	7.7
Malignant tumors.....	6.4	8.3	7.1
Infectious disorders.....	5.4	4.6	4.1
Brain disorders.....	10.6	9.8	6.6
Suicide.....	4.7	5.1	4.1
Various other diseases.....	21.1	24.8	30.5
Totals.....	100.0	100.0	100.0

cially the asthenic type, while pyknics comprise a rather high percentage of diabetics. The dysplastics are so few in number that they do not show any strikingly high percentages for any lesions.

And, with regard to low incidence diseases, those totalling below 10 per cent of a given disease group, he says (p. 809):

Few aortic aneurysms and cerebral hemorrhages occur in asthenic individuals. Pulmonary abscess and gangrene and bronchiectasis, as well as tuberculosis of the lungs, are rare in pyknics; few cases of nephritis, of prostatic carcinoma, of pachymeningitis and of adrenal hemorrhage occur in pyknics. The dysplastic group is represented by relatively few instances of hernia and of hemorrhagic pancreatitis.

TABLE 5
Body build related to disease

DISEASES	PER CENT OF CASES IN BODY GROUPS			
	Asthenic	Athletic	Pyknic	Dysplastic
Tuberculosis.....	66.3	17.4	2.3	14.0
Acute infections.....	41.1	28.4	14.7	15.8
Carcinomata (all).....	29.8	39.6	13.2	17.4
Syphilis (all forms).....	28.5	46.6	14.2	17.4
Violent death.....	20.0	36.7	30.0	13.3
Chronic Strep. infection..	16.3	39.5	22.1	22.1
Intestinal catastrophes....	15.7	31.6	21.1	31.6
Circulatory disasters.....	10.0	40.0	41.7	8.3
(Totals all cases, for comparison).....	33.4	36.5	15.6	14.5

for criticism will include inadequate criteria for morphological classification, inadequate size of sample, and insufficient statistical evaluation. Such objections may well be levelled at much of the work that has been done in studying the relation of morphology to disease. Yet considering only the work more carefully done there are so many reports that it would be not feasible here even to enumerate them adequately.

It is proposed, therefore, that some of the more important diseases be considered as indicative of the better investigations

carried out in this field. The psychoses will be discussed in a following section, as perhaps more properly to be considered, although definite "disease entities," in connection with the relation between morphology and psychology in constitution.

One approach to the study of the relation of morphological variation to pathology is the correlation of somatological habitus with the organs primarily involved in certain disease patterns. An excellent example of this technique is the study of Pearl, Gooch, Miner, and Freeman (223) of endocrine organ weights and bodily habitus. They summarize their findings as follows:

The average quantitative dosage of endocrine organ tissue per kilogram body weight is greatest in asthenics, less in intermediates ("athletics" of Kretschmer's terminology), and least in pyknics, so far as concerns adrenals, thyroid, parathyroids, hypophysis, epiphysis and gonads, while the relative dosage of thymus tissue is least in asthenics, greater in intermediates, and greatest in pyknics. The difference between the extreme types, asthenics and pyknics, in mean weights of endocrine organs is relative to body weight and generally large in amount, and without exception statistically significant having regard to their probable errors.

Several studies may be listed to indicate the wide variety of pathological fields that have been studied and have led to quite definite clinical conclusions. Benedetti (24) has studied sterility; Ciocco (53) auditory acuity; Lazarowitz (170) luetic aortitis; Freeman (93) has made further studies of the endocrines beside his contribution mentioned above; and Fici (89) has added to the list of workers who have studied the relationship between morphology and disease with apparently definite conclusions.

It is perhaps appropriate that Draper, one of the earliest careful American workers in this field, should be one of the main contributors. In his book *Human*

Constitution (69), published in 1924, he dealt with seven clinical entities: gall-bladder disease, ulcer (gastric and duodenal), nephritis and hypertension, pernicious anemia, asthma, tuberculosis, and acromegaly. Draper's techniques have been described elsewhere, and his attempts to recognize "disease races" have been discussed. He presents a mass of statistical data which is exceedingly hard to evaluate. This is essentially an application of anthropometric techniques to the field of medicine, and if it does not show anything else it does prove the difficulty if not the impossibility of using this method as an adequate approach to the problem. Aside from considerations of Draper's mechanisms of morphological evaluation, however, his findings are not without interest, and deserve careful study. In 1925, for example, he published (70) a study on the toxemias of pregnancy, supplementing earlier observations on hypertensives and nephritics, which showed that women suffering from these toxemias have morphological differentiae as compared with other groups which are statistically significant. Many other observations of interest to clinicians and anthropologists are to be found in his writings.

In more recent years Draper has extended his field of medical investigation, but has retained essentially the same idea of trying to differentiate "disease races" by suitable techniques, still chiefly anthropometric, although he has lately become more interested in the "physiologic panel" (see section II. B.). In 1934 he published, with Touraine (303), a study on 50 patients afflicted with classical migraine. He found some minor anatomic differences in these migrainous individuals as compared with a comparable "normal" population, such as: greater upper face (zygomatic) breadth;

shorter upper face height; higher facial index; more receding chin; more marked supraorbital ridges; larger teeth; a well-marked downward, inward slant of the upper eyelid; and narrower hands. In summary, these authors state (p. 2) that "it has not been possible by anthropometry alone to demonstrate beyond question a migrainous type morphologically." They have also studied the psychologic panel of these patients, find them to be arrested psycho-sexually, to have no deep religious ties, to have a "highly colored phantasy life", and conclude that migraine is a syndrome comparable to any neurosis.

2. Heart disease

Pearl and Ciocco in males (221), and Ciocco in females (54) have made very careful studies as to differences of body-build distinguishable from normals, in patients with heart disease. Using the same 13-point scale of morphological classification mentioned in connection with the study of endocrine organs above, they were not able in either males or females to find any significant difference between asthenics, intermediates, or pyknics as to the incidence of heart disease, but did note, particularly in females, that dysplasia is more common than in non-cardiacs. They found cardiac patients to be heavier, it is true, than non-cardiacs, but believed this to be due to "relative over-eating and lack of exercise," without inferring necessarily any etiological relationship in this respect.

Reed and Love (243a), using chiefly a height-weight relationship to determine somatological differences in a very extensive study of the development of disease in the United States Army, found that valvular diseases of the heart resulting from rheumatic fever and other infectious diseases were more frequent in tall thin

individuals, at advanced ages as well as in early adult life.

3. Arthritis

Kovacs and Hartung (156) have made a careful study of morphological differences between rheumatoid arthritis and osteoarthritis, essentially to examine the accuracy of the observation made by many, of a relationship between rheumatoid arthritis and the asthenic habitus, and between osteoarthritis and the pyknic habitus. They were careful to equate age and other variables in their statistical evaluation, and obtained the following results: the rheumatoid arthritis group had a tendency to increased longitudinal measurements, with longer and thinner necks; were slender though not necessarily tall, and had weights normal or under average for their age-sex groups; and the osteoarthritis group had a tendency to increased horizontal measurements, with shorter and thicker necks, more massive thoraces and abdomens; and had weights usually above average for corresponding age-sex groups. This seemed in general to confirm the work of earlier observers.

T. F. Goldthwaite (104) was among the earlier observers who pointed out an association of the light-boned, slender, asthenic individual with the rheumatoid form of arthritis. Millard Smith (279), on the other hand, felt that he could not distinguish any particular body type in atrophic arthritis, although he did not use particularly adequate methods for morphological classification, and did find the following percentages with the methods used: asthenic, 48 per cent; intermediate, 28 per cent; sthenic, 24 per cent. Young (333) noted slight morphological differences in children with rheumatism, was not sure that they were really significant, but concluded that such children

with rheumatism may "possibly even probably differ in constitutional traits" from control groups.

4. Tuberculosis

The disease now recognized as tuberculosis, especially in its pulmonary form, has been one of the clinical entities most intensively studied as to the rôle played in its development both by heredity and by constitutional variation. Some of the conclusions with regard to the former have been noted (see section II. D. 4.). And some mass statistics purporting to relate the disease to thin slender or asthenic individuals have been given. But the matter is not simple, and there is much conflicting opinion and evidence.

This is partly due to the nature of the disease, which apparently is an infectious disease, but in some respects does not behave as such. Historically, phthisis was considered as a general disease of the body as a whole that demanded treatment to increase the general bodily resistance. After discovery of the tubercle bacillus by Robert Koch in 1882, however, the idea of the constitutional disposition to tuberculosis was pushed into the background by the great interest in the bacteriological etiology of the disease. It is in the present third cycle of the investigation of the true etiology of tuberculosis that we find much conflicting evidence and opinion, much of the conflict being due to inadequate definition of the issues involved.

Barker (11) in a very thorough consideration of the whole subject seems to be entirely uncertain as to the possibility of a real constitutional factor in the disposition to tuberculosis. He finds a correlation between constitution and the development of the disease, it is true, but feels that because constitution has a high correlation with hereditary deter-

minants (an interesting observation in itself), this positive correlation is not so much due to constitution *per se* as it is to the hereditary factor. This seems to be begging the question, for he recognizes that the best use of the word constitution is to signify the human phenotype, including both genotypic and paratypic elements.

H. J. Halford (121) believed constitution, as determined by body weight proportions, not to be a significant factor in resistance to the infection, on the basis of averages for various stages of the disease (none, occult, quiescent, and manifest). But it is interesting to note that he found among children with pulmonary tuberculosis a high incidence of narrow chests. Hetherington (128), along the same line of investigation, did not find children with tuberculous infection, as measured by the tuberculin test, to be more frequently underweight than children with negative tests.

Satke (255) is typical of many who also are not sure of the rôle of constitutional disposition to tuberculosis. He points out that the phthisical habitus has been interpreted as being particularly susceptible to tuberculosis, but that many believe it to be the consequence of the disease. He also has difficulty distinguishing between "congenital resistance" and "constitutional resistance," but does finally admit that the asthenic habitus "is probably more susceptible to tuberculosis."

On the other hand there have been many workers who have found valid positive correlations between body build and predisposition to tuberculous infection. Typical of those writers who have found the slender, asthenic individual peculiarly liable to develop pulmonary tuberculosis are Beneke (29), Neuer and Feldweg (211), Saltykow (253), Stefko (288), Warstadt

and Collier (322), and Klare (150). Stiller (292, 293), among the older authors, associated with this type a definite lack of resistance to tuberculosis. Draper (69) notes one morphological point that is found quite often in tuberculous patients: a small (24° – 55°) subcostal angle. Ickert (140) notes that 80 per cent of tuberculosis patients are asthenic as compared with only 14–15 per cent of the general population. Luxemberger (184) concludes that there is a close correlation between the leptosomic habitus and tuberculosis. Wheeler (331), describing the two major human body types with great clarity, states that the linear or asthenic has a definite tendency to tuberculosis. Neumann (212) observes that the "asthenic-schizoid types are particularly susceptible" to tuberculosis. And Scammon and Petter (258) showed in a careful study that tuberculous children were below average weight for height, and weight for height for age.

Pryor and Mathiason (238) have done perhaps the most careful anthropometric study of tuberculous individuals. Comparing 210 tuberculous children with 6000 healthy children in the San Francisco area, equating age and sex, geographical and racial origin, and many other factors, they found that (a) the tuberculous children consistently varied from the average toward a slender build; (b) width-length indices were smaller for both sexes at all age levels in the tuberculous; (c) head and face measurements were smaller; (d) necks were longer and of smaller circumference; (e) chests were more barrel-shaped; and (f) nutrition was just as good in the tuberculous children, compared with the normal population, taking into account the more slender body build.

Bearing on points made by Halford and Pryor and Mathiason above, is the

interesting little book by Professor Weisman (324) of the University of Minnesota, with a foreword by Dr. Richard E. Scammon, entitled *Your Chest Should Be Flat*. Weisman with very adequately prepared statistics considers only the thoracic index but finds it definitely higher (thorax deeper in proportion to its breadth, or, narrower in proportion to its depth) in tuberculous children than in non-tuberculous controls. While interesting, his conclusions would seem to have more significance if they had been based upon a more comprehensive evaluation of the morphology involved in the disease than merely the thoracic index.

Reed and Love (243a) found that the majority of U. S. Army officers who developed tuberculosis were tall, spare individuals; and that they were clearly differentiated as to a height-weight relationship 10 and 20 years prior to the development of the disease.

Petersen (230), summing up all the evidence available on the subject of constitution and tuberculosis, and considering both the hereditary and morphological aspects, states categorically his opinion to be as follows (pp. 304–305): "Freedom from clinical tuberculosis depends on natural resistance and not immunity. There appears to be no escape from the conclusion. . . . Constitution, genotypic and paratypic, may therefore be the determining factor in an infectious disease such as tuberculosis." On the basis of the available evidence, Petersen's conclusions would seem to be warranted.

5. Gastro-intestinal disease

Next to lungs with tuberculosis, the abdomen seems to have been the favorite hunting ground of constitutional morphologists, with gall-bladder disease and ulcer the commonest diseases studied. Here should be mentioned again the work

of Draper (69), whose chief findings were that ulcer patients had longer, thinner necks than did cholecystitis patients, and a number of other minor similar morphological differences.

Ptois of the stomach and other abdominal organs has attracted a number of workers. Kaufmann (145), for example, examines 83 cases of "chronic digestive insufficiency," meaning chiefly chronic undernutrition, and found that 62 per cent (51) of these had "asthenic characters," employing Stiller's criteria. He finds a relationship between digestive insufficiency and ptois and asthenic habitus; and then adds, gratuitously, "ptotics have a longer life than the average"!

Fauszt and Augustin (86), employing observational, anthropometric, and statistical techniques, also investigated the relationship between ptois and body build, and found that asthenics had a definite tendency towards ptois. It is unfortunate in both these studies that the criterion for ptois is not more clearly stated, although Kaufmann does state he means ptois when the lesser curvature of the stomach is not above the level of the iliac crests. Todd (302), however, has shown that the position and shape of the stomach are highly variable, and is in part a function of the time of day, relation to mealtime, size of meal, nature of content, etc., and certainly these factors were not controlled adequately.

6. Gastric and duodenal ulcer

In the field of gastro-intestinal diseases the single entity that has been studied most often with regard to constitutional correlation has been peptic ulcer, both of the stomach and duodenum. This probably has been primarily because of the very common clinical observation of the frequency of the disease in individuals of linear build.

A cursory review of the literature on this particular subject reveals the trend of observations with regard to ulcer and the "asthenic habitus," chiefly as defined by Stiller. Stiller (292) himself in 1907 was one of the first to note the great frequency of ulcer in asthenics, and of the asthenic habitus in ulcer. Others who in general agreed with this observation through the earlier part of this century have been, in chronological order: Möller (202), 1911; Adolph Schmidt (260), 1913; Westphal (328), 1917; Kroug (163), von Krempelhuber (314), and Grote (114), 1919; and Kuttner (166), E. Schütz (263), and Strümpell (297) in 1920. It is well to keep in mind that constitutional morphological classification was still somewhat tentative and chaotic in this pre-Kretschmerian period.

Perhaps as a result of lack of clarity of definition of the various habitus pictures, there quickly appeared reports of several men who did not agree with the above, that the asthenic was necessarily correlated with predisposition to ulcer. Cohnheim (58) in 1921, e.g., in 1000 ulcer cases often found the body build to be quite heavy and robust, though he does not compare with controls. Hegemann (124) also in 1921 found among 100 ulcer patients only 15 individuals corresponding to Stiller's description of the asthenic, not a significant frequency. And von Bergmann (312) in the same year presented the interesting argument that there has been an observed antagonism between ulcer and tuberculosis in the same individual, that it was maintained that the asthenic was more susceptible to tuberculosis, and so how could both tuberculosis and ulcer be correlated with the asthenic habitus? Von Bergmann probably would have been more correct if he had suspected the relationship of the asthenic with

tuberculosis than with ulcer, in the light of later work.

At this stage of the modern evolution of clinical morphological taxonomy, Kretschmer contributed a large step forward in clarifying the picture. In the first editions of his book, *Physique and Character* (1918), in 1921 and 1922, Kretschmer was very vague as to an accurate description of the asthenic physique; and the photographs published did not lessen the confusion. But in later editions Kretschmer took great care to distinguish between two elements in the "asthenic habitus": (a) linearity, and (b) slenderness, fragility, gracility; and emphasized the latter quality, manifesting itself in various parts of the body, as the important variation in physique toward the upper end of the height-weight distribution. This kind of physique he then called "leptosome," no longer "asthenic." In other words, he recognized that linearity was part of both the leptosome and the athletic, but fragility, slenderness, *per se*, was a separate physical character. This also helped him better to recognize his "athletic" type, but still there was an inadequate delineation between athletic and pyknic.

Following this slight reformulation, further workers took up the study of ulcer and body build, now chiefly interested in the rôle of the "leptosome habitus." In 1923 Tscherning (305) found a significant preponderance of individuals with this habitus among ulcer patients, and in 1926 Ruhmann (252) in a well-prepared study confirmed Tscherning's observations.

Among still more recent workers, Fauszt and Augustin (86), already mentioned in connection with ptosis, noted that the leptosomic habitus is the "terrain for both ptosis of the stomach and gastric ulcer," but differentiated between the

leptosome and the musculo-athletic habitus, finding the latter a terrain for ulcers of the pylorus and duodenum. These authors used anthropometry carefully and employed rigid statistical techniques, and found significant differences in body build between patients with gastropotosis and gastric ulcer on the one hand, and pyloric and duodenal ulcers on the others, and no significant differences between gastropototic and gastric ulcer individuals, or between patients with pyloric and duodenal ulcers.

Goralewski and Schreiber (105), on the other hand, in a paper not at all well presented and giving no adequate statistics, do not believe it is possible to classify ulcer patients in a uniform constitutional picture on the basis of our present knowledge, if one tries rigidly to arrange them in any of the usual schemata, purely somatic or otherwise.

Caroli and Corman (49), in an extremely well prepared paper, do find significant differences between body build and ulcer, as well as the location of ulcer. They used only cases confirmed by clinical and roentgenological examination or by both and surgical intervention. Their morphological classification, based on observational techniques supplemented by several carefully selected measurements, divided the patients somewhat according to Stiller's scheme, into *longilignus* or linears, and *brévilignus* or laterals. Many interesting morphological points are noted by these authors, including the especially interesting one that the typical ulcer patient is one who is as much "athletic" as "asthenic," thus agreeing with observations made by Tscherning (305), Ruhmann (252), and Draper (69). In addition, they found it possible to establish the following rules: "The more the linear morphological type tends toward

the lateral, the greater is the frequency of localization of the ulcer in the duodenum; and the less pronounced the tendency to cicatrization." (49, p. 44.)

Draper's delineation of an "ulcer race" has already been mentioned. In two articles that well merit careful consideration, Feigenbaum and Howat (87, 88) of McGill, have reexamined Draper's thesis. They have used a sample of different racial stock in general, but otherwise have examined an approximately parallel cross-section of the disease population. They have practically repeated Draper's measurements on such patients. And it is their own conclusion (88, p. 454) that "on the whole the two sets of figures are comparable." They agree with Draper that ulcer patients have significantly longer necks than do gallbladder patients, that they have thinner, smaller chests, and proportionately longer limbs, and a few other similar observations. They employ a rigid statistical criterion for the determination of the significance of such differences.

But they found comparatively few differences between disease groups, of all the 37 measurements taken and eight indices calculated. In fact, they found that among the possible comparisons for both sexes only 19 per cent of the measures were significant in detecting differences, and only 6.6 per cent when both sexes were considered for the same measurement. They believe that if Draper had submitted his own data to a similar analysis similar results would have been obtained. From this analysis they are able to make the deduction (88, p. 449), "it can be stated categorically that the physical constitution of a patient is not a deciding factor in the etiology of peptic ulcer, cholecystitis, and diabetes." If they had made the additional reservation, "on the basis of this analysis,"

such a conclusion might be tenable. But it seems illogical, as has been pointed out elsewhere, to conclude that there must be a significant difference between all, or even a high proportion, of anthropometric measures, of all parts of the body, of two disease groups, before it is permissible to recognize significant differences in physical constitution. The chief contribution of Draper and Feigenbaum and Howat in this field would seem to be the futility of depending exclusively on anthropometric techniques in determining body build differences. It would seem more logical to use the careful scientific methods of Caroli and Corman, employing both observational and mensurational techniques. The argument for the scopometric analysis of the human body has been presented in a previous section (see IV. A.2.c.), as that which, on the basis of the best work done in this field, seems the best suited to give the most meaningful yet valid results.

In general, then, the work investigating the body build of ulcer patients seems nearly uniform in the conclusion that there is some relationship between body build and this particular disease diathesis.

7. Conclusions

Caroli and Corman (49), in concluding their paper, are so impressed with the possibilities of this constitutional approach to clinical medicine that they state, "It is possible to establish the greater or lesser frequency of each morphological type in the principal digestive diseases, and this recognition enables one to have at one glance a first impression which the clinical examination will often confirm." This seems, in essence, clearly and adequately to express the usefulness of the constitutional approach to the entire field of medicine.

D. Psychology

Research in constitutional psychology has been both scientific and pseudo-scientific.

1. Pseudo-scientific

Among the pseudo-scientific attempts to demonstrate that the body may reflect the personality are physiognomy and phrenology. It was the contention of Lavater (168) that by the analogy that each species of beast has a peculiar character as well as a peculiar form, one can infer that in man, too, predominant qualities of the mind are expressed by predominant forms of the body. Lavater made other analogies: "Large oranges have thick skins, and little juice. Heads of much bone and flesh have little brain. Large bones, with abundance of flesh and fat, are impediments to mind."

In the fourth volume of his *Essays on Physiognomy: For the Promotion of the Knowledge and the Love of Mankind* he presents one hundred rules to express the relations between various physical features and qualities of mind. According to Rule LXXVII, "A broad brown wart on the chin is never found in truly wise, calmly noble persons."

The foremost physiognomist of the present, Katherine Blackford (32), illustrates how far the "science" has departed from Lavater, for nowadays voice, color, texture of skin, bodily build, posture, gait, handshake, gestures, and clothing are also utilized. Applying her "law of color" to a study of blonds and brunettes, she describes the characteristics of each. Paterson and Ludgate (217), in examining the validity of her statements, discovered that the actual correlation is about zero. Physiognomy has been almost completely discredited by others, such as Kenaghy's (148) work on blond and brunette salesmen, Cleeton and

Knight's (56) survey of various character traits, Sommerville's (281) disproof of a relation between big noses and intelligence, and the celebrated work of Goring (106) on atavistic traits in criminals.

The pseudo-science of phrenology was fathered by Gall (96) and Spurzheim (283) over one hundred and fifty years ago. Believing that certain mental traits are localized in the brain, phrenologists reasoned that the great use of any particular trait would cause hypertrophy in that area, so that the bumps of the head revealed the mental characteristics dominating the person's total make-up. Modern findings cast doubt on our knowledge of brain localization, except for motor and sensory control, and neurology disproves the correspondence between contour of the brain and specific unevennesses of the skull. Pearson (226) in 1906 showed, moreover, that it is not true, as the phrenologists claim, that intellect and size of brain and skull go nicely hand in hand.

The physiognomic and phrenological systems of character analysis have a serious flaw. They assume that physical and mental traits exist as discontinuous and clear-cut units, whereas they probably are merely points in a curve of general distribution.

Although the postulates and methods of the pseudo-sciences physiognomy and phrenology have been in large part discredited, it is important not to reject completely the possibility of correlations existing between physique and personality, but to proceed with caution in this difficult but significant field.

2. Scientific

a. Intelligence and body-build

Numerous investigations have been carried on with the intention of proving or disproving a relationship between

body-build and intelligence. Some work seems to give positive indication that persons of greater stature and weight are of greater mental development. Among these may be cited Gowin's (108) indication that major executives in various fields are taller and heavier than minor ones in the same fields.

Due to the possibility that stature may add to a man's prestige because people, believing tall men *are* more capable, will rate them so, investigators in this field have turned their attention to children. Many results show taller children to be more intelligent, but most have employed faulty techniques and methods of analysis. The survey in Honolulu by Murdock and Sullivan (207), almost beyond reproach in method, reveals a correlation between height and intelligence that is so slight that it cannot be considered important. In fact, it may be concluded that though there is a slight positive correlation between intelligence and physical development (weight and stature), the relationship is not very important.

A somatotypic basis for intelligence has been both claimed and disproved. That it is the quality and not the quantity which varies with body build is the belief of Boldrini and Mengarelli (36), who, working with a group of 1000 Italian intellectuals (university professors), found leptosomes were inclined towards an abstract thought and pyknics toward technical and concrete thought. Naccarati (208) believed he had established the fact that microsplanchnics are more intelligent than macrosplanchnics. His index of body-build was height/weight, though he had expressed a preference for a different index, length of extremities/trunk volume, but this could not be utilized because not all the measurements were available. His groups were made up of insufficient numbers, men and

women were often intermingled, and there was a large percentage of Jewish students, a factor which might have greatly influenced the results.

The researches of Heidbreder (125), who avoided Naccarati's errors, gave essentially negative results, as did those of Stalnaker (285), Sheldon (272, 273), Garrett and Kellogg (98), and Somerville (281). Naccarati had approached his problem with an *a priori* belief that the endocrines were related to intelligence and body type.

A good summary of this general field is made by Paterson (215, 216) and Klineberg (151).

b. Body build and temperament and psychoses

Perhaps the major part of all the work done in trying to correlate body build and temperament has been an attempt to ascertain whether Kretschmer's theories are to be accepted as valid or not. For this reason we shall first of all describe his claims and their background.

The great psychiatrist Emil Kraepelin was the first to delineate the manic-depressive and schizophrenic ("dementia praecox") types of insanity. Following this, Bleuler (34) contributed a greater understanding of the symptoms and individual contents in schizophrenic processes. Reflecting on this classification, it occurred to Kretschmer that the boundaries between sickness and health were often quite blurred and that the two great form-groups which Kraepelin had "dragged out of the bewildering chaos of clinical phenomena" passed over in a gradual manner to healthy classifications of two corresponding kinds—"cyclothymic" and "schizothymic." He believed that ordinary people seemed to belong to one category or the other, but in addition it appeared to him that correlated with the two great types of disease and human

nature were certain morphological characteristics. In 1921, he first published his famous *Körperbau und Charakter* (158). Therein he described both the psychic and physical types, and how they were related to one another.

On the basis of clinical observations and a few measurements, he classified body types into asthenic (later called leptosomic), athletic, pyknic, and dysplastic groupings—very similar to the "combinations" of di Giovanni (68). These types were highly subjective, and Kretschmer believed that it was best that they be so. In general, Kretschmer found that the leptosomatic, athletic and dysplastic types were the schizophrenes and the pyknics the circulars.

Then Kretschmer went beyond the psychoses and included normal personalities. He recognized a gradual gradation from the psychoses to "normality"—circular insanity, to cycloid temperament, to cyclothymic personality; schizophrenic psychosis to schizoid to schizothyme.

Possible criticism of Kretschmer's work is overwhelming: small series; limits of the sampling (race); scantiness of measurements and absence of indices; use of subjective estimates; failure to classify data according to age, sex, intelligence, and social status, etc.

Yet, investigations to verify or disprove his ideas are numerous—a reflection of the far-reaching effect he has had on constitutional thought. It is difficult to say what the consensus of these investigations has been.

Wertheimer and Hesketh (327), in an endeavor to reduce the method of classification to a point where it could be handled statistically, devised an index whose values they hoped would express definite relation to the body types obtained from observation. Points on the frequency curve are used to classify the

asthenic, athletic, and pyknic types. They were unable to differentiate morphological types by the use of anthropometric measurements.

Von Rohden (317) tends in part to substantiate the Kretschmerian typology. Analysis of his data shows that the manic-depressive type is frequently pyknic, and seldom athletic or dysplastic; the epileptic is frequently athletic and dysplastic, seldom pyknic or leptosomic; the schizophrenic is frequently leptosomic and dysplastic, seldom pyknic and athletic.

In making his study von Rohden utilized weight and body measurements and defined his type through the use of nine separate indices of body-build (Pignet, Rohrer, etc.). It may be due to this difference in method of arriving at a typology that von Rohden's percentage of leptosomes is far greater than Kretschmer's. An additional factor operating in the same direction is that von Rohden procured his subjects not from among the Schwabians but the middle-Germans.

Although this study shows the manic-depressives to be overwhelmingly pyknic, it is amazing that the schizophrenes vary very little in percentage from the "normal" population. In other words, the characterization of the schizophrenic has little significance except as contrasted with the manic-depressive, who is really differentiated from the general population.

Cabot (47) quotes a number of workers having used essentially Kretschmer's typology in a study of psychoses, including among others Burchard (46), Campbell (48), Farr (85), Garvey (99), Gurewitsch (115), Lederer (171), Ossipowa (214), Shaw (270), Ssucharewa (284), and van der Horst (307). He summarizes with the statement (47, p. 23) that "... where subjects have been psychotic patients it has been shown that in general there is

a positive correlation between types of physical habitus and the schizophrenic and manic-depressive syndromes." Stevenson and associates (291) have sought to test the validity of Kretschmer's observations on a group of 100 male Chinese psychotics from Peiping hospitals, and quote a number of interesting similar studies on other Oriental stocks. The marked preponderance of leptosomatics which they found is hard to explain, unless it is because the authors have limited themselves to skeletal measurements only, though they have attempted to assay the influence of weight. This distribution is seen to be the more unusual as contrasted with the temperamental breakdown of the group: predominantly cyclothymic, 61; predominantly schizothymic, 30; with 9 individuals approximately equal. Racial considerations are well taken into account in the psychological evaluation. The authors conclude (p. 468): "... a psycho-physical correlation of the kind or degree required to conform to the Kretschmer hypothesis must be declared not proven." In view of the many factors to be taken into consideration in comparing their results with Kretschmer's, it is difficult accurately to evaluate their conclusions.

An important lead is suggested by the work of Connolly (59) on 100 male psychotic patients. He found that if paranoid dementia praecox subjects were separated out from the other dementia praecox groups they fall into a different type, namely, the pyknic, and in this respect are more allied to the manic-depressives, though they are even more robust than these in build. This serves as a reminder that negative results in constitutional research may often be laid to the door of our inadequate knowledge of the categories with which we are endeavoring to make correlations.

Connolly's results were somewhat anticipated in this respect by those of Freeman (92) published in 1934. He found that paranoids are to be grouped with persons of cycloid rather than schizoid personality.

European investigators claim a significant correlation between habitus types as classed by Kretschmer and many mental and sensori-motor performances. A summary of the work of Munz (206) and Enke (79) with the Rorschach test; of Scholl (261), Kibler (149) and Enke (79) with the tachistoscope; of Enke (82) with psycho-galvanic reflexes; of Pfahler (233) in the determination of perseverance; of the Russians with differential psychomotor responses and physiological functions; of Wertham (326) and Enke (80, 81) in perception span, reaction times, abstraction, *Spaltungsfähigkeit* or "cleavage capacity," sensitivity to color and form, word associations, affectivity tested by means of the psychogalvanic reflex, tapping rate, handwriting and intelligence; and of Kretschmer and Enke (160) in psychomotor and affective characteristics of athletics, seems to characterize the types as follows:

"... pyknics are more susceptible to color than either leptosomes or athletics; their associations are more colored by feeling than are those of subjects belonging to either of the other two groups; they excel in the description of details. Compared with leptosomes, pyknics are more synthetic, objective and adaptable in their mental disposition while their motor coordination is also superior. In handwriting, pyknics are freer, more labile and expansive than leptosomes. Compared with pyknics, leptosomes are more sensitive to form; their ability to dissociate is more marked and they are more "perseverative" in their associations; their descriptions are subjectively determined; they are emotionally restricted, analytical, abstract, inelastic, and they find it difficult to relax." (Cabot, 47, p. 23.)

American research does not, in general, substantiate these findings, although Sheldon (271) did find low correlations be-

tween body build and certain social traits. Klineberg, Asch and Block (152) divided a group of 153 male college students and 175 female college students into pyknics and leptosomes and tested for cancellation of numbers, incidental memory, *Spaltungsfähigkeit*, digit memory span, mental ability, scholastic aptitude and withdrawal aptitude. Correlations were found to be insignificant. These authors, who employed three different methods of classifying their subjects into the leptosome and pyknic groups, believe their study does not substantiate the presence of two psychological types in the normal population, though they make the reservation that Kretschmer's typology may nevertheless hold in cases of marked maladjustment. Klineberg and his associates suggest that the German workers dealt with persons of heterogeneous age, intelligence, social, economic and educational background; that their tests were of unknown reliability; and that they failed to employ measures of dispersion or to establish the significance of differences between measures. The German investigations have been surveyed in detail in a series of papers edited by Kroh (162).

On the other hand, Klineberg, Asch and Block may be regarded as unjustified in suspecting Kretschmer's types of being "another ballet of ghostly categories" for the reason that their criteria of psychological types—perceptual recognition, memory span, and general information—are not necessarily valid means of indicating differential responses. Kretschmer (158) attacks studies of this kind because

"The mathematical-experimental method suffers from a greater dearth of facts, and from the purely empirical standpoint, it invariably amounts to a clumsy abstraction which at best isolates a small number of factors from a complex of factors and treats them as representative of an infinitely more complex object." (Pp. 177-178.)

The total personality pattern, not isolated psychological traits, states Kretschmer, ought to be the basis of evidence.

The Russians have consistently substantiated Kretschmerian typology in children. Krasusky (157) found a clear connection, in Odessa children, between cyclothymic temperament and pyknic constitution, and between schizothymic temperament and leptosomic build. Constitutional and temperamental types are as evident among girls as boys in his series. The extensive researches by Ossipowa (214), Gurewitsch (115), Ssucharewa (284), Oseretsky, Lederer (171), Motschan, Coerper, Nikolajew and Jislin, centering around the Psychoneurological Clinic for Children at Moscow, have been devoted to applying Kretschmer's classifications to children.

In reviewing the researches made on Kretschmerian typology, then, it may be stated that whereas there has been general agreement that the manic-depressive and the schizophrenic psychoses bear some definite relationship to the pyknic and the leptosomic habitus, respectively, there is less certainty in dealing with the more normal cyclothymic and schizothymic personality patterns of such a relationship. Some claim that both morphological and psychological categories may be distinguished in early life—indeed, in infancy.

Brandt (40) also interprets the biological significance of the psychoses dealt with by Kretschmer. He says that the manic-depressive psychosis is a differentiative phenomenon of retarded physical development, passing into "mature old age," having expressed itself, biologically speaking, in the form of a simple, uncomplicated (one might say, metaphorically, "childlike") behavior. The schizoid psychosis, says Brandt, seems a biological phenomenon of accelerated

growth, and schizoids can even in childhood and puberty suddenly express themselves, biologically speaking, in the form of an infinitely complex, or "adult," pattern of behavior.

c. *Crime and morphology*

In his *Crime and the Man* Hooton (134) claims that there is an association between body build and type of crime. He recognizes that all body build types are likely to be associated with some particular kind of crime: "a short, fat man might under sufficient provocation murder his wife in complete defiance of his body build proclivities." The most striking of his findings, which take into consideration the influence of race and social condition, is the relationship between shortness and slenderness to burglary, larceny, and previous conviction; between tallness and murder; and between shortness and fatness and predilection for sex crimes. Among Negroes and Negroids, the various categories of offenders are physically almost as distinctive one from the other as is the case among whites.

Hooton is convinced that there is some sort of a relation between body build and temperament and behavior. His proof that rape and other sex offenses decrease with stature and increase with weight may, we believe, indicate support of the popular contention that short-legged men make the best lovers. The fact that tall slender men "seem completely uninterested in this type of activity" suggests the possibility of hypogonadism.

One naturally wonders what Hooton discovered in connection with Lombroso's belief that criminal behavior is a primitive or atavistic phenomenon and that criminals may have physical anomalies, not possessed by the law-abiding, which are of *atavistic* or *degenerative*

origin. Lombroso and his followers intermingled these two theories, which are really quite different, in that atavism is a reversion to a primitive or subhuman type of man, and degeneracy is due to the cessation of progressive evolution and the beginning of devolution. Both of these theories emphasize the hereditary basis of antisocial conduct and the biologically anomalous character of the criminal.

Hooton's vast survey shows that criminals "do not bear the brand of Cain, nor any specific physical stigmata whereby they can be identified at a glance." This contradicts Lombroso's claim that there are but two types of men, normal and criminal, and that the skulls of criminals bear larger percentages of primitive and pathological features. But Hooton did find that among whites, particularly among Old Americans, criminals are biologically inferior to civilians. This was not true among Negro and Negroid criminals; in fact, the criminals in some ways appeared to have stronger and more vigorous physiques than non-criminals.

Approaching the Lombrosian theory in another way, Hooton studied Negroes and Negroids. For if criminal behavior is a primitive or atavistic phenomenon, Negroes should show "a purer distillation of criminality associated with primitive characters than among the more sophisticated and possibly more degenerate whites." It was considered valid to make this inquiry because it is only a few generations since the Negroes in this country were possessed of a primitive African culture. The analysis indicates no substantiation for Lombroso. Negro and Negroid are prone to murder, but commit less rape and other sex offenses, less burglary and larceny, than many of the nine white racial types. If these

people are lower in forms of criminal activity other than homicide, it might be argued that certain social and economic forces are at work. The problem is truly a complicated one.

Lombroso's theory had been severely attacked in 1913 by Charles Goring (106), a medical officer in the English prison service. Goring appears, like Hooton, to have discredited the Italian criminologist, but actually did not wholly do so, as has been commonly supposed. Hooton speaks extremely harshly of Goring's use of "his statistical genius to distort the results of his investigation to conformity with his bias," a bias which Goring himself professed at the outset of his book, *The English Convict* (106, pp. 24-25). According to Hooton, he was "an evangelical humanitarian" who perverted evidence, made objectionable and illegitimate use of statistical processes and sophistries, etc.

As a matter of fact, while disbelieving in Lombroso's doctrines, Goring nevertheless came to the conclusion that the criminal diathesis is an actual fact, and that it consists of a biological inferiority. "There is no such thing as an anthropological criminal type," said Goring,

"but despite this negation and upon the evidence of our statistics, it appears to be an equally indisputable fact that there is a physical, mental, and moral type of normal person who tends to be convicted of crime: that is to say, our evidence conclusively shows that on the average, the criminal of English prisons is markedly differentiated by defective physique—as measured by stature and body weight; by defective mental capacity—as measured by general intelligence; and an increased possession of wilful anti-social proclivities—as measured, apart from intelligence, by length of sentence to imprisonment." (Pp. 269-270, *abr. ed.*)

Goring stressed the constitutional factor in criminals and placed it above the environmental. It is to be noted that

Goring, like Hooton, differentiates the body build of criminals according to their offense. For example, "tall persons are relatively immune from conviction of rape," and "crimes of violence are associated with the finer physique, health, and muscular development." In view of this, it is surprising to see the statement that "he did not solve the problem of the relation of the offense to criminal physique."

In connection with the belief that the criminal is biologically inferior, it is to be noted that von Rohden's work indicates it is the athletic who shows the highest frequency of criminality relative to his proportion of the general population. This is at variance with Hooton's belief that the biological inferiority of the criminal is expressed by his linearity or smallness of transverse dimensions. Von Rohden (317, pp. 495-496) cites the findings of Michel and Böhmer, who both found that the athletics constituted 56 per cent of the criminals whom they investigated. Since Hooton is not completely clear as to why he regards certain body-types as inferior, his conclusions must be accepted with caution, especially since he bases much of his eugenical program on this assumption.

E. Survey of research

It is now possible to conclude that, imperfect as is modern constitutional methodology, many definite results have been obtained. These chiefly show presence or absence of relationship between morphological elements of the constitution and other biological variables that are susceptible of objective evaluation. In the field of physiology, definite results are not numerous; in pathology, a not inconsiderable body of evidence would suggest that for many diseases consti-

tutional factors are largely determinant as to their development and course; and in the field of psychology more tenuous conclusions may be drawn as to the relationships between morphological variations and preponderance of certain psychological traits.

Attempting to see the entire problem of constitution in perspective, it seems clear that one reason why more positive information has not been obtained is the obvious fractionation of the entire field of biology. Thus the program suggested by many and proposed by Professor Hooton of Harvard (133), of a study of constitutional problems by scientists from at least the fields of anthropology, biology and psychology, working together as a unit, seems to merit serious if cautious consideration:

The purposes of such an institute for research in applied human biology might be enumerated as follows: to establish ranges, norms and variabilities in the fields of human morphology, physiology, psychology and neurology; to investigate age changes in man from his conception to his dissolution; to determine racial susceptibilities and immunities; . . . to investigate human heredity and to apply the results of such research to medical practice; to lay the foundations of a rational science of eugenics.

The job is huge, the prospect discouraging, but the benefits to man himself from such a program are potentially enormous.

VI. SUMMARY AND CONCLUSIONS

(1) Examining the history of man's reflections upon the nature of his own constitution, it is evident that the subject has been given serious thought in every period of recorded history. Early emphasis was first upon "humoral," then on "temperamental" differentiation; in more recent times, as more has become known of man's inner structure, certain assumptions have been made correlating organs and systems with behavior, and

these have become, in more refined form, the beginnings of modern endocrinology; the contemporary period has been characterized, until quite recently, by a relative neglect of the study of constitutional factors in man for the more spectacular research into the nature of environmental forces as they affect man, following the great scientific advances of the last two generations. But through every period of change in attitude, man has been seriously speculating about his body and its behavior, and wondering about their interrelations.

(2) It is generally agreed that the nature of man's constitution is his entire biological make-up, largely determined by the genetic factors of his heredity, but influenced to an indeterminate extent by environmental forces. Other closely related factors are race and sex. For the sake of convenience, constitution may be divided into morphological, physiological and psychological aspects, with pathology possible in each, to be considered an "abnormal" variation of certain biological properties from an individual or group mean. Heredity is observed to be the major determinant of the morphological aspect of constitution, with environment, including the passage of time, playing a minor rôle; in the physiological aspect, and still more in the psychological, biological behavior is less related to heredity, more influenced by environment; both heredity and environment exert an appreciable influence on the development of disease, depending chiefly on the kind of pathology involved, but disease is never entirely independent of inherited factors. Morphological, physiological, and psychological aspects of man's constitution, as determined by both heredity and environment (and their correlated factors, race and sex), all

essentially are integral parts of man as a "complete psychosomatic being," and it is necessary constantly to keep in perspective this unity in dealing with the complexities of constitutional problems.

(3) The usefulness of a study of man's constitution, from both theoretical and practical standpoints, is seen to be more accurate prediction, in a true statistical sense, of biological behavior. Constitutional investigation is to be regarded as an additional arrow in man's quiver of available methodology for the solution of many biological unknowns, that he may the better control his own destinies, both as an individual and as a species.

(4) The means by which man's constitution may be investigated have been elaborated by modern scientists—physical anthropologists, biologists, psychologists, clinicians—and are well known. Modern biometric analysis of data so obtained is of material assistance in avoiding errors of interpretation. Constitutional study today consists chiefly of investigating relationships between the more fixed morphological elements of man and the less fixed, the physiological, pathological, psychological. Fruitful study of such correlations depends on adequate systems of classification, and such are generally lacking in nearly all fields of constitutional investigation, especially the last named, the less fixed aspects.

(5) In morphology, however, distilled from the observations of many men over a period of many years, a valid and meaningful taxonomy seems to be condensing, in which may be recognized basic elements, or components, of body build, which give promise of meeting the demands of a system of classification heretofore unsatisfied. Seemingly the most significant system of morphological classification developed recognizes three

basic components existing simultaneously in every individual, each varying in a "normal" continuous distribution—but in a different dimension—when man is studied in the mass.

Such a system, employed in one modified form or another by most investigators, has led to many positive and many negative conclusions, when morphology has been correlated with other aspects of constitution. Negative results have in many cases been due to technical imperfections of investigation, or to limited scope and perspective in making the study; and in many cases, in well conceived, carefully executed researches, have demonstrated true absence of correlation between the variables selected for investigation. Positive results, too, have been attended by faulty technique and limited scope; but even in these studies, and especially in the more adequate investigations, which are increasing in number, there is accumulating sufficient evidence to indicate that modern constitutional studies are contributing much that is valid and illuminating to man's greatest game: his quest for the truth about himself.

It is being determined, for instance, that all men are no more physiologically alike than they are anatomically, within certain ranges of variation; and that such morphological and physiological variations have much to do with the development of a long list of disease entities to which man is subject, and even, perhaps, with certain criminal tendencies. And even in the field of psychology, where man nearly transcends his human qualities in trying to understand his understanding, much is being ascertained to the effect that as man *is* determined, morpho-physiologically, by combinations

of hereditary and environmental forces, so is he likely, within rather wide limits, to function as a more or less rational—yet always human—animal.

(6) Such is the promise, indeed, of many adequately controlled scientific investigations in the field of constitutional studies, that it would seem logical to advance further the plan advocated by many, of an integrated attack on problems

of human constitution as a joint enterprise of scientists trained in anthropology, medicine and psychology, in the form of some closely-knit organization for constitutional research.

The authors wish to take this opportunity to acknowledge their indebtedness to Dr. W. M. Krogman, without whose stimulation, assistance, and kindly criticism and advice, this paper would not have been written.

LIST OF LITERATURE

1. ADAMANTIUS: In FORRESTER, R.: *Scriptores Physiognomici Graeci et Latini*. Leipzig (B. G. Teubner), 1893.
2. ADDISON, THOMAS: *Collection of the Published Writings*. London, 1868.
3. ALONS, C. L.: De erfelijke Factor in de Aetiologie van de Tuberculose. *Groningen* (J. B. Wolters), 1928.
4. AMANO, K.: The influence of the climate on the human body, with special reference to baseball matches. *Taiwan Igakkai Zasshi* (Abstr. Sect.), 31: 38, April, 1932.
5. ARISTOTLE: *Physiognomonica*. Trans. into English by T. Loveday and E. L. Forster: *The Works of Aristotle*. Oxford (Clarendon Press), 1913, Chap. I.
6. ARNOLD, A.: Ein weiterer Beitrag zur Einwirkung der Leibesübungen auf den wachsenden Körper. *Ztschr. f. Konstitutionslehre*, 16: 409-420, 1932.
7. AVICENNA: *A Treatise on the Canon of Medicine of Avicenna*. Trans. into English by O. C. Gruner. London (Luzac and Co.), 1930.
8. BAKWIN, H., and BAKWIN, R. M.: Types of body build in infants. *Am. J. Dis. Child.*, 37: 461-472, 1929.
9. BARBÁRA, M.: De signis humorum in toto corpore praedominantium. *Endocrinol. e pat. costit.*, 3: 52-59, 1928.
10. BARDEEN, C. R.: The height-weight index of build in relation to linear and volumetric proportion, etc. *Carnegie Inst. of Wash., Contributions to Embryology*, no. 46, 483-552, 1920.
11. BARKER, L. F.: The relations of the make-up of the body to the disposition to tuberculous infections and their course. *Am. Rev. Tuberc.*, 30: 519, Nov., 1934.
12. BARTELS, V.: Gymnastics and dietary regime for the pyknic type. *Fortschr. d. Med.*, 52: 963-964, Oct. 22, 1934.
13. BAUER, J.: *Vorlesungen über allgemeine Konstitutions- und Vererbungslehre*. Berlin (Julius Springer), 1923.
14. —: Die konstitutionelle Disposition zu inneren Krankheiten. Berlin (Julius Springer), 1924.
15. —: Phänomenologie und Systematik der Konstitution und deren dispositionelle Bedeutung auf somatischem Gebiet. In *Handbuch der normalen und pathologischen Physiologie*. Berlin, 1926, vol. 17.
16. —: *Innere Sekretion: Ihre Physiologie, Pathologie, und Klinik*. Berlin (Julius Springer), 1927.
17. —: Bibliographie der Konstitutionslehre. *Ztschr. f. Konstitutionslehre*, 15: 268-315, 1929.
18. —, et al: Bibliographie der Konstitutionslehre. *Ztschr. f. Konstitutionslehre*, 18: 161-204, 1931.
19. BAUER, K. H.: Homotransplantation von Epidermis bei eineiigen Zwillingen. *Beitr. z. klin. Chir.*, 141: 442, 1927.
20. BEAN, R. B.: Morbidity and morphology. *Bull. Johns Hopkins Hosp.*, 23: 363, 1912.
21. —: Some characteristics of the external ear of American whites, American Indians, American Negroes, Alaskan Esquimos, and Filipinos. *Am. J. Anat.*, 18: 201-226, 1915.
22. —: The two European types. *Am. J. Anat.*, 31: 359, 1923.
23. BENEDETTI, P.: Das Problem der Disposition zur Krebskrankheit. *Ztschr. f. Konstitutionslehre*, 16: 261-291, 1931.
24. —: *Costituzione e Fecondità*. Bologna (L. Cappelli), 1932.
25. —: Über die Konstitutionstypenbestimmung mittels anthropometrischer Indices. *Ztschr. f. Konstitutionslehre*, 17: 180-198, 1933.

26. BENKE, F. W.: Die anatomische Grundlagen der Konstitutionsanomalien des Menschen. *Marburg*, 1878.
27. —: Altersdisposition. *Marburg*, 1879.
28. —: Über das Volumen des Herzens. *Schriften d. Gesellsch. Med. Marburg*, 1879, supplement 2.
29. —: Konstitution und konstitutionelles Kranksein des Menschen. *Marburg*, 1881.
30. BERNHEIM-KARRER, J.: Ernährungsstudien an eineiigen Zwillingen. *Ztschr. f. Kinderb.*, 47: 427, 1929.
31. BERNSTEIN, F.: Heredity of blood groups. *Klin. Wchnschr.*, 3: 1495-1497, Aug. 12, 1924.
32. BLACKFORD, K. M. H., and NEWCOMB, ARTHUR: The Job, the Man, the Boss. *New York* (Doubleday, Page and Co), 1919.
33. BLATZ, W. E., et al.: Collected Studies of the Dionne Quintuplets. *Toronto* (University of Toronto Press), 1937.
34. BLEULER, E.: Körperliche und geistige Konstitutionen. *Naturwissenschaften*, 9: 753, 1921.
35. BOGEM, E.: Racial susceptibility to tuberculosis. *Am. Rev. Tuberc.*, 24: 522, Nov., 1931.
36. BOLDRINI, M., and MENGARELLI, C.: Caratteri costituzionali di un gruppo di intellettuali. *Comit. Ital. Stud. Prob. Popol. Atti, Roma*, 3: 195, 1933.
37. BORCHARDT, L.: Klinische Konstitutionslehre. *Berlin u. Wien* (Urban und Schwarzenberg), 1924.
38. —: Funktionelle und trophische Momente als Ursachen des gegensätzlichen Verhaltens von Pyknikern und Asthenikern. *Ztschr. f. Konstitutionslehre*, 16: 1, 1931.
39. BORNEHARDT, A.: Die Körperwägungen der Einberufenen als Mittel zur Bestimmung der Tauglichkeit zum Militärdienst. *St. Petersburg. med. Wchnschr.*, 3: 108-111; 196-197, 1886.
40. BRANDT, W.: Die biologischen Unterschiede des Pyknikers und des Leptosomen. *Deutsche med. Wchnschr.*, 62: 501-502, March 27, 1936.
41. BROCK, J., and BROCKMANN, A. W.: Zur Kenntnis der Körperproportionen während des Wachstums. *Ztschr. f. Kinderb.*, 56: 226-236, 1934.
42. BRUGSCH, T.: Allgemeine Prognostik oder die Lehre von der ärztlichen Beurteilung des gesunden und kranken Menschen. *Berlin u. Wien* (Urban und Schwarzenberg), 1918.
43. —: Die Morphologie der Person. In Brugsch, T., and Lewy, F. H.: Die Biologie der Person. *Berlin u. Wien* (Urban und Schwarzenberg), 1926-1931, 2: 1-114, 1931.
44. BRUGSCH, T., and LEWY, F. H.: Die Biologie der Person. Ein Handbuch der allgemeinen und speziellen Konstitutionslehre. *Berlin u. Wien* (Urban und Schwarzenberg), 1926-1931.
45. BRYANT, J.: The carnivorous and herbivorous types of man. *Boston M. and S. J.*, 170: 795, 1914; 172: 321, 1915; 173: 384, 1915.
46. BURCHARD, E. M. L.: Physique and psychosis—An analysis of the postulated relationship between bodily constitution and mental disease syndrome. *Comp. Psych. Monog.*, 13: no. 61, 1936.
47. CABOT, P. S. DE Q.: The relationship between characteristics of personality and physique in adolescents. *Genetic Psychology Monographs*, vol. 20, no. 1, Feb., 1938.
48. CAMPBELL, J. K.: The relation of the types of physique to the types of mental diseases. *J. Abnorm. and Social Psychol.*, 27: 147-151, 1932.
49. CAROLI, J., and CORMAN, L.: La Constitution Morphologique des Ulcèreux. *Arch. d. mal. de l'app. digestif*, 25: 26-56, Jan., 1935.
50. CASTALDI, L.: Accrescimento Corporeo e Costituzioni dell' Uomo. *Firenze* (L. Niccolai), 1928.
51. CELSUS, AURELIUS CORNELIUS: On Medicine. *London* (E. Cox), 1831, vol. 1.
52. CHAILLOU, A., and MACAULIFFE, L.: Morphologie Médicale. *Paris*, 1912.
53. CIOCCO, A.: Hearing acuity and middle ear infections in constitutional types. *Acta otolaryng.*, 18: 365-380, 1933.
54. —: Studies on constitution: III. Somatological differences associated with diseases of the heart in white females. *Human Biol.*, 8: 38-91, Feb., 1936.
55. —: The historical background of the modern study of constitution. *Bull. Inst. Hist. Med.*, 4: 23-38, 1936.
56. CLETON, G. U., and KNIGHT, F. B.: Validity of character judgments based on external criteria. *J. Appl. Psychol.*, 8: 215-229, 1924.
57. COERPER, C.: Über die Gestaltung der klinischen Konstitutions- und Erbforschung. *Deutsche med. Wchnschr.*, 61: 715-719, May 3, 1935.
58. COHNHEIM, P.: Beitrag zur Diagnostik und Aetiologie der Magen- und Zwölffingerdarm-Geschwüre usw. *Arch. f. Verdauungskr.*, 27: 241, 1921.
59. CONNOLLY, C. J.: Physique in relation to psychosis. *Stud. in Psych. and Psychiat.*,

- Washington (Catholic Univ. of America Press), *Monograph serial* no. 5, vol. 4, 1939.
60. CURTIUS, F.: Über erbliche Beziehungen zwischen eineiigen und "zweieiigen" Zwillingen und die Zwillingsvererbung im Allgemeinen. *Ztschr. f. Konstitutionslehre*, 13: 286, 1928.
 61. —, and KORKHAUS, G.: Klinische Zwillingsstudien. *Ztschr. f. Konstitutionslehre*, 15: 229, 1931.
 62. DAVENPORT, C. B.: The height-weight index of build. *Am. J. Phys. Anthropol.*, 3: 467-475, 1920.
 63. —: Body-build, its development and inheritance. *Carnegie Institution of Washington*, Publication 329 (Paper no. 3 of the Dept. of Eugenics), 1923.
 64. DAY, H. G.: Some biochemical and physiological aspects. In Greulich, W. W., Day, H. G., Lachman, S. E., Wolfe, J. B., and Shuttleworth, F. K.: A Handbook of Methods for the Study of Adolescent Children. *Washington, Monographs of the Society for Research in Child Development*, vol. 3, no. 2, serial no. 15, 1938.
 65. DE HAËN: Rationis Medendi Vien. Caust. Part 10, 1765; part 11, 1767.
 66. DELLA PORTA, GIAMBATTISTA: De Humana Physiognomonica. Libri IIII (Josephum Cacchium), 1586.
 67. DE TROISVÈRE, F. T.: Cited by Draper (71, p. 99).
 68. DI GIOVANNI, A.: Clinical Commentaries Deduced from the Morphology of the Human Body. Trans. into English from the 2nd Italian edition by J. J. Eyre, London and New York, 1919.
 69. DRAFER, G.: Human Constitution: A Consideration of Its Relationship to Disease. *Philadelphia and London* (W. B. Saunders Co.), 1924.
 70. —: Studies in human constitution: III. Physical types in relation to the toxemias of pregnancy. *Am. J. M. Sc.*, 170: 803-810, Dec., 1925.
 71. —: Disease and the Man. *London* (Kegan Paul, Trench, Trubner and Co.), 1930.
 72. —: Man as a complete organism, in health and disease. *New York State J. Med.*, 34: 1052-1063, Dec. 15, 1934.
 73. —: The common denominator of disease. *Am. J. M. Sc.*, 190: 545-558, Oct., 1935.
 74. —, BRAUNN, H. G., and DUFRATIS, C. W.: Changes in the electrocardiogram as criteria of individual constitution as derived from its physiological panel. *Am. J. M. Sc.*, 194: 514-523, Oct., 1937.
 75. DREYFUS, G.: Die Inanition im Verlauf von Geisteskrankheiten und deren Ursachen, *Arch. f. Psychiat.*, 41: 519, 1906.
 76. DROLET, G. J.: The inheritance factor in tuberculosis: Predisposition or immunity, *Am. Rev. Tuberc.*, 10: 280, 1924.
 77. ELSHOLZIUS, J. S.: Anthropometria. *Patavia* (Typis Jo. Bap. Pasquati), 1654, section 9.
 78. EMMERSON, and MANNY, F. A.: Weight and height in relation to malnutrition. *Arch. Pediat.*, 37: 468, 1920.
 79. ENKE, W.: Die Konstitution im Rohrschach'schen Experiment. *Ztschr. f. d. ges. Neurol. u. Psychiat.*, 108: 645-674, 1927.
 80. —: Experimentalpsychologische Studien zur Konstitutionsforschung (Sinnes- und denpsychologische Untersuchungen). *Ztschr. f. d. ges. Neurol. u. Psychiat.*, 114: 770-794, 1928.
 81. —: Experimentalpsychologische Studien zur Konstitutionsforschung (Psychomotorische Untersuchungen). *Ztschr. f. d. ges. Neurol. u. Psychiat.*, 118: 798-817, 1929.
 82. —: The affectivity of Kretschmer's constitutional types as revealed in psycho-galvanic experiments. *Character and Personality*, 3: 225-233, 1933.
 83. ESQUIROL, J.: Folie. *Dictionnaire des Sciences Médicales*, Vol. 16, Paris, 1816.
 84. EVERETT, F. R.: The pathological anatomy of pulmonary tuberculosis in the American Negro and in the white race. *Am. Rev. Tuberc.*, 27: 411-464, May, 1933.
 85. FARR, C. B.: Bodily structure, personality and reaction types. *Am. J. Psychiat.*, 7: 231-244, 1927-1928.
 86. FAUSZT, I., and AUGUSTIN, V.: Der Habitus der Magenkranken. *Deutsche med. Wchnschr.*, 61: 1846-1849, Nov. 15, 1935.
 87. FEIGENBAUM, J., and HOWAT, D.: The relation between physical constitution and the incidence of disease: The disease groups include peptic ulcer, cholecystitis and diabetes mellitus. *J. Clin. Investigation*, 13: 121-138, Jan., 1934.
 88. —, and —: Physical constitution and disease: II. Absence of correlation between the anatomic constitution and predisposition to diabetes mellitus, cholecystitis and peptic ulcer. *Arch. Int. Med.*, 55: 445-456, March, 1935.

89. FICI, V.: Fisiopatologia dei tipi morfologici costituzionali. *Endocrinol. e pat. costis.*, 1: 321-375, 1926.
90. FISCHER, E.: Die Rehebother Bastards und das Bastardierungsproblem beim Menschen; Anthropologische und ethnographische Studien am Rehebother Bastardvolk in Deutsch-Südwest Afrika. *Jena* (G. Fischer), 1913.
91. FLEISCHNER, E. C.: The relation of weight to measurements of children during the first year. *Arch. Pediat.*, 23: 739, 1906.
92. FREEMAN, W.: Human constitution: A study of the correlations between physical aspects of the body and susceptibility to certain diseases. *Ann. Int. Med.*, 7: 805-811, 1934.
93. —: The weight of the endocrine glands: Biometric studies in psychiatry: 8. *Human Biol.*, 6: 489-523, 1934.
94. FRIEDENREICH, V.: Blood groups and genetics. *Ann. Genetics*, 8, part 2, Jan., 1938.
95. GALENUS: De Temperamentis. Th. Linacro interprete. *Contabrigium* (Joannem Siberch), 1521. Reproduced in facsimile; *Cambridge* (Macmillan and Bowers), 1881.
96. GALL, F. J.: Cited by Ciocco (51, p. 25).
97. GANTHER, R., and ROMINER, E.: Über die Bedeutung des Handleistenbildes für die Zwillingsforschung. *Ztschr. f. Kinderb.*, 36: 212, 1923.
98. GARRETT, H. E., and KELLOGG, W. N.: The relation of physical constitution to general intelligence, social intelligence and emotional stability. *J. Exper. Psychol.*, 11: 113-129, 1928.
99. GARVEY, C. R.: Comparative body build of manic-depressives and schizophrenic patients. *Psychol. Bull.*, 30: 567-568, 1933.
100. GERBER, E.: Die Bestimmung des Ernährungszustandes aus Gewicht und Länge. *Med. Klinik*, 17: 1261, 1921.
101. GREYER, H.: Der Trinkversuch bei eineiigen und zweieiigen Zwillingen. *Klin. Wchnschr.*, 10: 1488, 1931.
102. GILDEA, E. F., KAHN, E., and MAN, E. B.: The relationship between body build and serum lipoids and a discussion of these qualities as pykophilic and leptophilic factors in the structure of the personality. *Am. J. Psychiat.*, 92: 1247-1260, 1936.
103. GOLDTHWAIT, J. E.: An anatomic and mechanistic conception of disease. *Boston M. and S. J.*, 172: 881, 1915.
104. GOLDTHWAITE, T. F.: Our Present Understanding of Rheumatic Diseases. *Milwaukee*, 1911.
105. GORALEWICKI, v.G., and SCHNEIDER, A.: Zur Konstitutionsfrage bei Ulcus ventriculi und duodeni. *Deutsche med. Wchnschr.*, 63: 128-129, Jan. 22, 1937.
106. GORING, C.: The English Convict. *London* (H. M. Stationery Office), 1913; abridged edition, 1919.
107. GOTTFREIN, A.: Allgemeine Epidemiologie der Tuberkulose. *Berlin* (Julius Springer), 1931.
108. GOWIN, E. B.: The Selection and Training of the Business Executive. *New York*, (Macmillan Co.), 1918.
109. GRAVES, W. W.: The relations of scapular types to problems of human heredity, longevity, morbidity and adaptability in general. *Arch. Int. Med.*, 34: 1-26, 1924.
110. —: A note on the possible relation of blood groups to age and longevity. *Ann. Int. Med.*, 8: 747-751, Dec., 1934.
111. —: The age-incidence principle of investigation in evaluating the biological significance of inherited variations in the problems of human constitution. *Am. J. Psychiat.*, 93: 1109-1117, 1937.
112. GRUBLICH, W. W., and THOMA, H.: Pelvic type and its relationship to body build in white women. *J. A. M. A.*, 112: 485-493, Feb. 11, 1939.
113. GRIMES, E.: Studies in the natural history of phthisis. *Am. Rev. Tuberc.*, 28: 80-92, July, 1933.
114. GROTE, L. R.: Über den Einfluss der Konstitution usw. Sammlung zwangloser Abhandlung usw., 6, 1919-1920.
115. GUREWITSCH, M.: Motorik, Körperbau, und Charakter. *Arch. f. Psychiat.*, 76: 521-532, 1926.
116. GUTTMAN, W.: Ist eine objective Beurteilung des Ernährungszustandes des Menschen möglich. *Arch. f. Kinderb.*, 72: 1923, 1922.
117. HACKEL, W.: Pathologisch-anatomische und anthropometrische Studien über Konstitution. *Ztschr. f. Konstitutionslehre*, 16: 63-80, 1932.
118. HÄCKER, V.: Die entwicklungsgeschichtliche Vererbungsregel in der Völkerkunde. *Ztschr. f. Indukt. Abstammungs- u. Vererbungslehre*, 19: 73, 1918.
119. —: Neuere Wege der menschlichen Erblichkeitsforschung. *Med. Klinik*, 18: 1218, 1922.
120. HALFORD, F. J.: Tuberculosis in the Hawaiian: A study of school-children of Hawaiian blood. *Am. Rev. Tuberc.*, 28: 370-380, Sept., 1933.
121. HALFORD, H. J.: The practitioner's library. *Pediatrics*, vol. 7, p. 1033.

112. HARRIS, J. A.: The measurement of man in the mass. In HARRIS, J. A., JACKSON, C. M., PATTERSON, D. G., and SCAMMON, R. E.: The Measurement of Man. *Minneapolis* (University of Minnesota Press), 1930.
113. HAUCHMANN, S.: Indices als Bestimmer des Konstitutionstypus. *Zschr. f. Konstitutionslehre*, 14: 679-693, 1929.
114. HROGMANN, W.: Über die angeblichen Beziehungen des Ulcus ventriculi zum asthenischen Habitus und zur Lungentuberkulose. *Med. Klinik*, 13, 1921.
115. HENDEREDER, E.: Intelligence and the height-weight ratio. *J. Appl. Psychol.*, 10: 52-62, March, 1926.
116. HENCKEL, K. O.: Konstitutionstypen und europäische Rassen. *Klin. Wchnschr.*, 4: 2145, 1925.
117. HESS, A. F., and BLACKBERG, S. N.: Constitutional factors in the etiology of rickets. *Am. J. Physiol.*, 102: 8, 1932.
118. HETHERINGTON, H. W.: Malnutrition in Childhood and Tuberculous Infection. P. 459.
119. HIPPOCRATES: On Ancient Medicine: The Genuine Works of Hippocrates. Trans. into English by F. Adams, *New York* (Wm. Wood and Co.).
120. HIRSCH, N.: Heredity and Environment. *Cambridge, Mass.* (Harvard University Press), 1930.
121. HNAT, F.: The importance of the study of human constitution in the practice of medicine. *J. M. Soc., New Jersey*, 30: 557-559, Aug., 1933.
122. HOOTON, E. A.: Up from the Ape. *New York* (Macmillan Co.), 1931.
123. —: Apes, Men, and Morons. *New York* (G. P. Putnam's Sons), 1937.
124. —: Crime and the Man. *Cambridge, Mass.* (Harvard University Press), 1939.
125. HOUGHTON, H. A.: The hyposthenic constitution as a hazard of anesthesia. *Anesth. and Analg.*, 15: 47-52, Jan.-Feb., 1936.
126. HRDLÍČKA, A.: Physiological and medical observations among Indians of southwestern United States and northern Mexico. *Bureau of American Ethnology Bull.*, 34, Washington, 1908.
127. HUNTER, J.: The Works of John Hunter, with Notes. Edited by J. F. Palmer, *London*, 1835, vol. 1.
128. HUTCHINSON, JONATHAN: The Pedigree of Disease. *London* (Churchill), 1884.
129. HUYER: Cited by von Rohden (319).
130. ICKERT, F.: Über Tuberkuloseformen in dünnbesiedelten Gegenden Ostpreussens. *Beitr. z. Klin. d. Tuberk.*, 75: 253-262, 1930.
131. JACKSON, C. M.: Normal and abnormal types. In HARRIS, J. A., JACKSON, C. M., PATTERSON, D. G., and SCAMMON, R. E.: The Measurement of Man. *Minneapolis* (University of Minnesota Press), 1930.
132. JOHANNSEN, W.: Elemente der exakten Erblchkeitslehre. Ed. 3, *Jena* (G. Fischer).
133. JOHNSON, W. M., and MYERS, J. A.: Tuberculosis in Infants and Primitive Races. *Am. Rev. Tuberc.*, 28: 381-409, Sept., 1933.
134. KATASE, A.: Der Einfluss der Ernährung auf die Konstitution des Organismus. *Berlin* (Urban und Schwarzenberg), 1931.
135. KAUFMANN, W.: Die chronische Verdauungsinsuffizienz; ihre Beziehungen zum asthenischen Körperbau; ihre Begutachtung und Behandlung. *Arch. f. Verdauungskr.*, 57: 293-302, May, 1935.
136. KAUP, J.: Bedeutung des Normbegriffes in der Personallehre. In BRUGSCH, T., and LEWY, F. H.: Die Biologie der Person. *Berlin u. Wien* (Urban und Schwarzenberg), 1926, vol. 1, pp. 191-225.
137. KELLY, H. G.: A study of individual differences in breathing capacity in relation to some physical characteristics. *Univ. of Iowa Studies, Studies in Child Welfare*, 7: 28-34, no. 5, 1933.
138. KENAGHY, H. G.: Do blonds make the best salesmen? *Sales Management*: 325-328, Feb., 1923.
139. KIBLER, M.: Experimentalpsychologischer Beitrag zur Typenforschung. *Zschr. f. d. ges. Neurol. u. Psychiat.*, 98: 524-544, 1925.
140. KLARE, K.: Die Konstitution im tuberkulösen Geschehen. *Deutsche med. Wchnschr.*, 64: 845, June 10, 1938; 64: 887, June 17, 1938.
141. KLINBERG, O.: Race Differences. *New York and London* (Harper Bros.), 1935.
142. —, AICH, S. E., and BLOCK, H.: An experimental study of constitutional types. *Genetic Psychology Monographs*, 16: 145-221, 1934.
143. KONJETZNY, G. E.: Del diagnóstico precoz del carcinoma del estómago. *Rev. méd. germano-ibero-am.*, no. 5-6, 194-200, 1937.
144. —: Eine besondere Form der chronischen hypertrophischen Gastritis unter dem klinischen und röntgenologischen Bilde des Carcinoms. *Chirurg*, 10: 260-268, no. 8, 1938.
145. KORÁNYI, A.: Zur Kritik der Methodik der Konstitutionslehre. *Wien. Arch. f. inn. Med.*, 27: 169-177, 1935.
146. KOVACS, J., and HARTUNG, E. F.: Constitution and arthritis. *J. Lab. and Clin. Med.*, 21: 1022-1027, 1936.

157. KRASUSKY, W. S.: Kretschmer's konstitutionelle Typen unter den Kindern im Schulalter. *Arch. f. Kinderb.*, 82-83: 22-32, 1927.
158. KRETSCHEMER, E.: Körperbau und Charakter. Trans. from the 2nd revised and enlarged German edition into English, as "Physique and Character," by W. J. H. Sprott. *London* (Kegan Paul, Trench, Trubner and Co.), 1925 and 1936.
159. —: The experimental method treated as an instrument of psychological investigation. *Charac. and Person.*, 3: 175-180, 1933.
160. —, and ENKE, W.: Die Persönlichkeit der Athletiker. *Leipzig* (Georg Thieme), 1936.
161. KROGMAN, W. M.: The inheritance of non-pathological physical traits in man. *Eugenical News*, 21: 139-146, no. 6, Nov.-Dec., 1936.
162. KROH, O. (Ed.): Experimentelle Beiträge zum Typen. *Ztschr. f. Psychol.*, 14: 1-300, 1929.
163. KROUG: Das Magenulkus. *Jena*, Diss., 1919.
164. KUGELMAN, I. N.: Growing Superior Children. *New York* (Appleton-Century), 1935.
165. KÜHNEL, G.: Die Indexberechnung der weiblichen Körperbautypen. *Ztschr. f. d. ges. Neurol. u. Psychiat.*, 134: 528-555, 1931.
166. KUTTNER: Das Ulcus duodeni. *Verhandl. d. Gesellsch. f. Verdauungs- u. Stoffwechselkr.*, 1920.
167. LANDSTEINER, K., and LEVINE, P.: On the cold agglutinins in human serum. *J. Immunol.*, 12: 441-460, Dec., 1926.
168. LAVATER, JOHN CASPAR: Essays on Physiognomy: for the Promotion of the Knowledge and the Love of Mankind. Trans. into English by Thomas Holcroft. Ed. 2, vols. 4, *London* (C. Whittingham), 1804.
169. LAYCOCK, T.: Physiognomical diagnosis. *Med. Times and Gazette*, 1: 1, 1862.
170. LAZAROWITZ, L.: Die Rolle der Konstitution bei der Entwicklung der spätluetischen Veränderungen, in erster Reihe der Aortitis. *Wien. klin. Wchnschr.*, 45: 1583-1589, 1932.
171. LEDERER, R.: Konstitutionspathologie in den medizinischen Spezialwissenschaften. *Berlin* (Julius Springer), vol. 1.
172. LENZ, F.: Erblichkeitslehre im Allgemeinen und beim Menschen im Besonderen. *Handbuch der Normalen und Pathologischen Physiologie. Berlin* (Julius Springer), 1926, vol. 17, 901.
173. LEWIS, P. A., and WRIGHT, S.: Further observations on heredity as influencing natural resistance to tuberculosis. *Tr. Nat. Tuberc. Assn.*, 17: 275, 1921.
174. LITTLE, C. C.: Civilization Against Cancer. *New York* (Farrar and Rinehart), 1939.
175. LIVI, R.: Anthropometria. *Milano*, 1886.
176. —: L'indice ponderale o rapporto tra la statura e il peso. *Atti della Soc. Romana di Antropologia*, 5: 125-153, 1898.
177. LOBB, L.: Heredity and Internal Secretion in the Etiology of Cancer. Communication to the International Cancer Conference in London, July, 1928.
178. LOMBROSO, C.: L'Uomo Delinquente. Ed. 4, *Torino* (Flli. Bocca), 1889.
179. LORENTZ, F. H.: Der bestimmende Konstitutionsindex und die neue Konstitutionsformel. *Deutsche med. Wchnschr. (Festschr. d. Sportärztesch.: XI. Olympischen Spielen)*, pp. 39-40, 1936.
180. LOVE, A. G., and DAVENPORT, C. B.: Defects Found in Drafted Men. Statistical Information Compiled from the Draft Records. *Washington*, 1919.
181. LUCAS, W. P., and PRYOR, H. B.: Physical measurements and physiological processes in young children. *J. A. M. A.*, 97: 1127, 1931.
182. —, and —: The body build factor in the basal metabolism of children. *Am. J. Dis. Child.*, 46: 941-948, Nov., 1933, part 1.
183. —, —, BOET, C., and POPP, S. T., JR.: Growth problems: II. Basal metabolic rate variations in relation to body build, adolescence and allergy in children. *J. Pediat.*, 3: 856, 1933.
184. LUXEMBURGER, H.: Heredität und Familientypus der Zwangsneurotiker (anankastischen Psychopathen). *Arch. f. Psychiat.*, 12: 590, 1930.
185. MACAULIFFE, L.: Les origines de la morphologie humaine. *Bull. de la Soc. d'Étude des Formes Humaines*, nos. 2 and 3, 155, 1925.
186. MANNY, F. A.: Indexes of nutrition and growth. *Mod. Hosp.*, 7: 425, 1916.
187. MANOUVRIER, L.: Étude sur les rapports anthropométriques en général, et sur les principales proportions du corps. *Mém. de la Soc. d'Anthr. de Paris*, 1902, Sér. iii, T. ii.
188. MARTIN, R.: Lehrbuch der Anthropologie: In systematischer Darstellung: Mit besonderer Berücksichtigung der anthropologischen Methoden. 3 vols., *Jena* (Gustav Fischer), 1928, pp. 231-234.
189. —, and BACH, F.: Größen- und Massen-Verhältnisse beim Menschen. *Tabulas Biol.*, 3: 617-719, 1926.

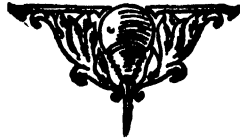
190. MARTIUS, F. H. A.: Konstitution und Vererbung in ihren Beziehungen zur Pathologie. *Berlin* (Julius Springer), 1914.
191. —: Die Lehre von den Ursachen in der Konstitutionspathologie. *Deutsche med. Wchnschr.*, 44: 449-481, 1918.
192. MATUSEWICZ, J.: Der Körperlänge—Körpergewichts—Index bei Münchener Schulkinder. *Munich*, 1914.
193. MAYR-GROSS, W.: Kretschmer's Körperbaulehre und die Anthropologie. *München. med. Wchnschr.*, 69: 676, 1922.
194. MAZER, C., MERANZE, D. R., and ISRAEL, S. L.: Evaluation of the constitutional effects of large doses of estrogenic principle. *J. A. M. A.*, 105: 257-263, July 27, 1935.
195. McCLOY, C. H.: Appraising physical status and the selection of measurements. *University of Iowa Studies, Studies in Child Welfare*, vol. 12, no. 2, March 15, 1936.
196. —: Appraising physical status: Methods and norms. *University of Iowa Studies, Studies in Child Welfare*, vol. 15, no. 2, April, 1938.
197. MÜLLER, E.: Types of Mind and Body. *New York* (W. W. Norton and Co.), 1927.
198. —: Appendix to Kretschmer's "Physique and Character" (1918).
199. MILLS, R. W.: The relation of body habitus to visceral form, position, tonus and motility. *Am. J. Roentgenol.*, 4: 155, 1917.
200. MOHR, G. J., and GUNDLACH, R. H.: The relation between physique and performance. *J. Exp. Psychol.*, 10: 117-157, 1927.
201. MÖLLENHOFF, F.: Zur Frage der Beziehungen zwischen Körperbau und Psychose. *Arch. f. Psychiat.*, 71: 98, 1924.
202. MÖLLER, S.: Die Pathogenese des Ulcus ventriculi usw. *Ergebn. d. inn. Med. u. Kinderh.*, 7: 520, 1911.
203. MONTEMORI, M.: Pedagogical Anthropology. Trans. into English from the Italian by FredERIC Taber Cooper, *New York* (Stokes), 1913.
204. MÜLLER, O.: Die Kapillaren der menschlichen Körperoberfläche. *Stuttgart* (F. Enke), 1922.
205. MÜNTER, H.: Lungentuberkulose und Erbllichkeit. *Beitr. z. Klin. d. Tuberk.*, 76: 257, 1930.
206. MUNZ, E.: Die Reaktion des Pyknikers im Rohrschach'schen psychodiagnostischen Versuch. *Ztschr. f. d. ges. Neurol. u. Psychiat.*, 91: 26-92, 1924.
207. MURDOCK, K., and SULLIVAN, L. R.: A contribution to the study of mental and physical measurements in normal children. *Am. Phys. Educ. Rev.*, 28: 209-215, 276-280, 328-330, 1923.
208. NACCARATI, S.: The morphologic aspect of intelligence. *Arch. Psychol.*, no. 45, Aug., 1921.
209. NABOHL, O.: Die de Vriessche Mutationstheorie in ihrer Anwendung auf die Medizin, Antrittsrede. *Zurich*, 1918. Also in: *Ztschr. f. ang. Anat.*, 6: 33, 1920.
210. —: Allgemeine Konstitutionslehre. *Berlin* (Julius Springer), 1927.
211. NEUER, I., and FELDWEBG, P.: Körperbau und Lungenphthise. *Ztschr. f. Konstitutionslehre*, 13: 88, 1928.
212. NEUMANN, W.: Tuberkulose und Konstitution. *Wien. klin. Wchnschr.*, 43: 47, Jan. 9, 1930.
213. NEWMAN, H. H., et al.: Twins: A Study of Heredity and Environment. *Chicago* (University of Chicago Press), 1937.
214. OSTPOWA, E. A.: Körperbau, Motorik und Charakter der Oligophrenen: I. *Ztschr. f. d. ges. Neurol. u. Psychiat.*, 114: 1-21, 1928.
215. PATERSON, D. G.: Personality and Physique. In HARRIS, J. A., JACKSON, C. M., PATERSON, D. G., and SCAMMON, R. E.: The Measurement of Man. *Minneapolis* (University of Minnesota Press), 1930.
216. —: Physique and Intellect. *Century Psychology Series*. *New York* (The Century Co.), 1930.
217. —, and LUDGATE, K. E.: Blond and brunette traits: A quantitative study. *J. Person. Res.*, 1: 122-127, July, 1922.
- 217a. PATON, D. N., and FINDLAY, L.: Poverty, Nutrition and Growth. Studies of Child Life in Cities and Rural Districts of Scotland. *Medical Research Council, Special Report Series*, no. 101, *London* (His Majesty's Stationery Office), 1926.
218. PEARL, R.: The relative influence of the constitutional factor in the etiology of tuberculosis. *Am. Rev. Tuberc.*, 4: 688-712, 1920.
219. —: Biological factors in Negro mortality. *Human Biol.*, 1: 229-249, 1929.
220. —: Constitution and Health. *London* (Kegan Paul, Trench, Trubner and Co.), 1933.
221. —, and CROCCO, A.: Studies on constitution: II. Somatological differences associated with diseases of the heart in white males. *Human Biol.*, 6: 650-713, 1934.
222. —, GOOCH, M., and FREEMAN, W.: A biometric study of the endocrine organs in relation to mental disease. Part I. *Human Biol.*, 7: 350-391, 1935.
223. —, —, MINER, J. R., and FREEMAN, W.: Studies on constitution: IV. Endocrine organ weights and somatological habitus types. *Human Biol.*, 8: 92-125, Feb., 1936.

224. PEARL, R., and PEARL, R. D.: Studies on human longevity: VI. The distribution and correlation of variation in the total immediate, ancestral longevity of nonagenarians and centenarians in relation to the inheritance factor in duration of life. *Human Biol.*, 6: 98-222, 1934.
225. —, SUTTON, A. C., HOWARD, W. T., JR., and RIOCH, M.: Studies on constitution: I. *Human Biol.*, 1: 10-56, 1929.
226. PEARSON, K.: Relationship of intelligence to size and shape of the head and other mental and physical characters. *Biometrika*, 5: 105-146, 1906.
227. —: The hereditary factor in tuberculosis. *Lancet*, 2: 891, 1920.
228. PENDE, N.: Constitutional Inadequacies. Trans. into English from the Italian by S. Naccarati. *Philadelphia* (Lea and Febiger), 1928.
229. PERRIER, C.: L'oreille et ses rapports avec la taille, la grande envergure, le buste, le pied, le crâne chez les criminels. *Paris* (A. Maloine et fils), 1925.
230. PETERSEN, W. F.: Constitution and disease. *Physiol. Rev.*, 12: 283-308, Apr., 1932.
231. —, and LEVINSON, S. A.: The skin reactions, blood chemistry and physical status of "normal" men and of clinical patients. *Arch. Path.*, 9: 151, 1930, part 2.
232. —, and WILLIS, D. A.: Capillary permeability and the inflammatory index of the skin in the normal person as determined by the blister. *Arch. Int. Med.*, 38: 663, 1926.
233. PFÄHLER, G.: System der Typenlehren. *Ztschr. f. Psychol.*, 15: 1-334, 1929.
234. PFUHL, W.: Die Beziehungen zwischen Rassen- und Konstitutionsforschung. *Ztschr. f. d. ges. Anat.*, Abt. 2: *Ztschr. f. menschl. Vererb.- u. Konstitutionslehre*, 9: 172, 1923.
235. PIGNET: Du coefficient de robusticité. *Bull. médicale*, 15^e ann.: 373-376, 1901.
236. PLATTNER, W.: Metrische Körperbaudiagnostik. *Ztschr. f. d. ges. Neurol. u. Psychiat.*, 151: 374-404, 1934.
237. POLEMONIS: In FOERSTER, R.: *Scriptores Physiognomici Graeci et Latini*. Leipzig (B. G. Teubner), 1893.
238. PRYOR, H. B., and MATHIASON, H.: An anthropometric study of tuberculous children. *Am. Rev. Tuberc.*, 33: 348-369, March, 1936.
239. QUETELET, A.: *Anthropométrie*. Bruxelles (C. Muquardt), 1871.
240. RAUTMANN, H.: Zur ärztlichen Untersuchung der deutschen Studentenschaft. *Deutsche med. Wchnschr.*, 50: 565, 1924.
241. RAUTMANN, H.: Untersuchungen über die Norm, ihre Bedeutung und Bestimmung. *Jena* (Gustav Fischer), 1926.
242. —: Die Kollektivmasslehre in der klinischen Medizin. *Arch. f. Gynäk.*, 130: 563, 1927.
243. —: Weitere Untersuchungen über die relative Variabilität des Körpergewichtes. *Ztschr. f. d. ges. Anat.*, 13: 519, 1928.
- 243a. REED, L. J., and LOVE, A. G.: Biometric studies on U. S. Army Officers: Somatological norms in disease. *Human Biol.*, 5: 61-93, 1933.
244. RIPPY, E. L.: Physical types and their relation to disease. *Dallas M. J.*, 22: 112-115, Nov., 1936.
245. RITALA, A. M.: Inheritance of constitution of the parents by the new-born child as demonstrated by body measurements: Records of height and weight measurements of pregnant women. *Acta med. fenn. duodecim* (ser. B, parts 1-3, no. 20), 23: 1-56, 1935.
246. RITTERHAUS, E.: Beitrag zur Frage: Rasse und Psychose. *Zentralbl. f. d. ges. Neurol. u. Psychiat.*, 44: 253, 1926.
247. ROHRER, F.: Der Index der Körperfülle das Mass des Ernährungszustandes. *München. med. Wchnschr.*, 68: 580, 1921.
248. —: Die Kennzeichnung der allgemeinen Bauverhältnisse des Körpers durch Indexzahlen. *München. med. Wchnschr.*, 68: 850-851, 1921.
249. RÖMLE, R.: Innere Krankheitsursachen. *Aschoff's Pathologische Anatomie*, 1: 1, 1923.
250. —, and ROULET, F.: Mass und Zahl in der Pathologie. *Berlin* (Julius Springer), 1932.
251. ROSTAN, L.: *Cours élémentaire d'Hygiène*. 2 vols., ed. 2, Paris, 1828.
252. RUHMANN, W.: Der Ulcusranke: Studien zur Konstitution und Symptomatik am gesamten Status bei chronischem Ulcus pepticum mit besonderer Berücksichtigung des vegetativen Nervensystems. *Berlin* (S. Karger), 1926.
253. SALTYKOW, S.: Tuberkulose und Konstitution. *Verhandl. d. deutsch. path. Gesellsch.*, 24: 133, 1929.
254. —: Zur näheren Kennzeichnung der einzelnen Konstitutionen. *Virchow's Arch. f. path. Anat.*, 275: 616-637, 1929.
255. SATKE, O.: Die konstitutionelle Disposition zur Tuberkulose. *Wien. klin. Wchnschr.*, 43: 1348, Oct. 30, 1930.
256. SCAMMON, R. E.: The Measurement of the Body in Childhood. In HARRIS, J. A., JACKSON, C. M., PATERSON, D. G., and SCAMMON, R. E.: *The Measurement of Man*. Minneapolis (University of Minnesota Press), 1930.

257. SCAMMON, R. E., and CALKINS, L. A.: The Development and Growth of the External Dimensions of the Human Body in the Fetal Period. *Minneapolis* (University of Minnesota Press), 1929.
258. —, and PRITZER: Studies of Children at Lymanhurst School for Tuberculous Children. *Minneapolis*. Cited by Pryor and Mathiason (238).
259. SCHENFELD, A.: You and Heredity. *New York*. (Stokes Co.), 1939.
260. SCHMIDT, A.: Klinik der Darmkrankheiten. *Wiesbaden*, 1913.
261. SCHOLL, R.: Untersuchungen über die Teilnahlidliche Beachtung von Farbe und Form bei Erwachsenen und Kindern. *Ztschr. f. Psychol. u. Physiol. d. Sinnesorg.*, 101: 225-280, 1927.
262. SCHULTZ, A.: Fetal growth of man and other primates. *QUART. REV. BIOL.*, 1: 465, Oct., 1926.
263. SCHÜTZ, E.: Über intermittierenden Krankheitsverlauf beim Magen- und Zwölffingerdarmgeschwür und über das Nischensymptom. *Wien. klin. Wchnschr.*, p. 336, 1920.
264. SEASHORE, C.: *University of Iowa Studies in Psychology*, 2: 46-54, 1899.
265. —: Phonophotography as a New Approach to the Psychology of Emotion. Feelings and Emotion. The Wittenberg Symposium. *Worcester, Mass.* (Clark University Press), 1928, pp. 206-211.
266. —: Speech. *University of Iowa Studies*, Ser. Aims Prog. Res., 1933, no. 41.
267. —: Piano Touch. *Sci. Mon.*, N. Y., 47: 360-365, 1937.
268. —: Musical Intelligence. *Music Ed. J.*, 24: 32-33 (no. 5), 1938.
269. SEROT, G.: Le varietà umane. *Atti Soc. romana d'antrop.*, 1: 1, 1893.
270. SEAW, F. C.: A Morphologic Study of the Functional Psychoses. *State Hosp. Quart.*, 10: 413-421, 1924-1925.
271. SHELTON, W. H.: Social traits and morphological types. *Personnel Journal*, vol. 6, no. 1, 1927.
272. —: Ability and facial measurements. *Personnel Journal*, vol. 6, no. 2, 1927.
273. —: Morphological types and mental ability. *J. Person. Res.*, 5: 447-451, 1927.
274. —: The Varieties of Human Physique: An Introduction to Constitutional Psychology. *New York* (Harper and Bros.), 1940.
275. —: Personal communication to the authors.
276. SIMMONS, H. W.: Zwillingspathologie. *Berlin* (Julius Springer), 1924.
277. STAUD, C.: La Forme Humaine. *Paris* (A. Maloine), 1914.
278. SLYS, M.: Cancer and heredity. *Ann. Int. Med.*, 1: 951, 1927.
279. SMITH, M.: A study of one hundred and two cases of atrophic arthritis. *New England J. Med.*, 206: 103, 1932.
280. SNYDER, L. H.: Human blood groups: Their inheritance and racial significance. *Am. J. Phys. Anthropol.*, 9: 233-263 (no. 2), 1926.
281. SOMMERVILLE, R. C.: Physical, motor and sensory traits. *Arch. Psychol.*, 12: 1-108, 1924.
282. SPIGELIUS, ADRIANUS: Opera—Omnia Quae Extant. *Amsterdam*, 1645.
283. SPURZHEIM, J. G.: Phrenology in Connexion with the Study of Physiognomy. *Boston* (Marsh, Capen and Lyon), 1833.
284. SUCHAREWA, G. E.: Körperbau, Motorik, und Charakter der Oligophrenen: II. *Ztschr. f. d. ges. Neurol. u. Psychiat.*, 114: 22-37, 1928.
285. STALNAKER: Cited by Paterson (215).
286. Standard Classified Nomenclature of Disease. H. B. LOOIS [Ed.]. *New York* (The Commonwealth Fund), 1935.
287. STEDMAN, T. L.: A Practical Medical Dictionary. Ed. 10, *New York* (Wm. Wood and Co.), 1928, p. 782.
288. STEFKO, W.: Die morphologischen Eigentümlichkeiten der Nagelfalzkapillaren und ihre konstitutionelle Bedeutung. *Ztschr. f. Konstitutionslehre*, 15: 317, 1931.
289. STERN-PIPER, L.: Kretschmer's psycho-physische Typen und die Rassenformen in Deutschland. *Arch. f. Psychiat.*, 67: 569, 1923.
290. —: Konstitution und Rasse. *Ztschr. f. d. ges. Neurol. u. Psychiat.*, 86-265, 1923.
291. STEVENSON, P. H., SUNG, S. M., PAI, T., and LYMAN, R. S.: Chinese constitutional differentiation and Kretschmerian typology. *Human Biol.*, 9: 451-481, Dec., 1937.
292. STILLER, B.: Die asthenische Konstitutionskrankheit. *Stuttgart* (F. Enke), 1907.
293. —: Grundzüge der Asthenie. *Stuttgart* (F. Enke), 1916.
294. STOCKARD, C. R.: Human types and growth relations. *Am. J. Anat.*, 31: 261, 1923.
295. —: The Physical Basis of Personality. *New York* (W. W. Norton and Co.), 1931.
296. STRINA, F.: The question of the existence of a special somatic type of unmarried mothers. *Gior. veneto di sc. med.*, 10: 756-766, Nov., 1936.
297. STRUMPFELL: Spezielle Pathologie und Therapie. Ed. 22. 1920, vol. 1, pp. 629 ff.

298. TANDLER, J., and GROZ: Die biologische Grundlagen der sekundären Geschlechtscharakter. *Berlin*, 1913.
299. TEDESCO, P. A.: Le costituzioni morfologiche dei Cagliaritari durante l'accrescimento dai 12 ai 19 anni. *Endocrinol. e pat. costit.*, 6: 403-520, 1931.
300. THOMSEN, O., FRIEDENREICH, V., and WORSAAE, E.: Über das Verhältnis zwischen A- und B-Rezeptor in der AB-Gruppe. *Ztschr. f. Rassenphysiol.*, 3: 20-26, Aug. 15, 1930.
301. THODIS, A.: La Vie par le Stade. *Paris*, 1924.
302. TODD, T. W.: Behavior Patterns of the Alimentary Tract. *Baumont Foundation Lectures*, Series no. 9, *Baltimore* (Williams & Wilkins Co.), 1930.
303. TOURAINE, G. A., and DRAFER, G.: The migrainous patient—A constitutional study. *J. Nerv. and Ment. Dis.*, 80: 1, July; 183, Aug., 1934.
304. TREAGOLD, H. A.: Functional efficiency and body-build in the young male adult. *Lancet*, 1: 1377-1382, June 30, 1934.
305. TSCHEERNING, R.: Über die somatische und psychische Konstitution bei *Ulcus ventriculi*. *Arch. f. Verdauungskr.*, 31: 351-360, 1923.
306. TSCHEERNORUTZKY, M. W.: Wechselbeziehungen zwischen Funktionseigenschaften und Konstitutionstypus. *Ztschr. f. Konstitutionslehre*, 15: 134, 1931.
307. VAN DER HORST: Experimentell-psychologische Untersuchungen zu Kretschmer's "Körperbau und Charakter." *Ztschr. f. d. ges. Neurol. u. Psychiat.*, 93: 341-380, 1924.
308. VIOLA, G.: L'habitus phthisicus et l'habitus apoplecticus comme conséquence d'une loi qui déforme normalement le type moyen de la race en ces deux types antithétiques. *Compt. rend. de l'Assoc. d. anat. Vingt-troisième réunion, Turin*, 6-8 avril, 1925, pp. (of reprint) 33, 1925.
309. —: La costituzione individuale. *Bologna* (L. Cappelli), 1933.
310. —: Il mio metodo di valutazione della costituzione individuale. *Riforma med.*, 51: 1635-1638, no. 43, Oct. 26, 1935.
311. VOLLMER, H.: The shape of the ear in relation to body constitution. *Arch. Pediat.*, 54: 574-590, Oct., 1937.
312. VON BERGMANN: Handbuch der inneren Medizin. Vol. 1, pt. 3, p. 731.
313. VON DUNOERN, E., and HIRSCHFELD, L.: Über gruppenspezifische Strukturen des Blutes. *Ztschr. f. Immunitätsforsch. u. exper. Therap.*, 8: 516-562, 1921.
314. VON KREMPFELHUBER: Zur Pathogenese des runden Magengeschwürs. *Deutsche med. Wchnschr.*, no. 40, 1919.
315. VON PIRQUET: *Ztschr. f. Kinderh.*, 6: 253, 1916.
316. VON ROHDEN, F.: Über Beziehungen zwischen Konstitution und Rasse. *Ztschr. f. d. ges. Neurol. u. Psychiat.*, 98: 255, 1925.
317. —: Konstitutionelle Körperbau-Untersuchungen an Gesunden und Kranken. *Arch. f. Psychiat.*, 79: 786-815, 1927.
318. VON VERSCHUER, O.: Die Wirkung der Umwelt auf die anthropologischen Merkmale nach Untersuchungen an eineiigen Zwillingen. *Arch. f. Rassen- u. Gesellsch.-Biol.*, 17: 149, 1925.
319. —: Die vererbungsbiologische Zwillingsforschung. Ihre biologischen Grundlagen. Studien an 102 eineiigen und 45 gleichgeschlechtlichen zweieiigen Zwillings- und an 2 Drillingspaaren. *Ergeb. d. inn. Med. u. Kinderh.*, 31: 35, 1927.
320. WAGNER, R.: Die Zahlenmässige Beurteilung des Ernährungszustandes durch Indices. *Ztschr. f. Kinderh.*, 28: 38, 1921.
321. WALKINGTON, T.: The Optick Glass of Humors; or, The Touchstone of a Golden Temperature. *London* (E. May), 1664.
322. WARSTADT, A., and COLLIER, W. A.: Über den angeblichen Zusammenhang von Schizophrenie und Tuberkulose. *Allg. Ztschr. f. Psychiat.*, 103: 355-365, 1935.
323. WEIDENREICH, F.: Rasse und Körperbau. *Berlin* (Julius Springer), 1926.
324. WEISMAN, S. A.: Your Chest Should Be Flat. Foreword by R. E. Scammon. *Philadelphia* (J. B. Lippincott Co.), 1938.
325. WEITZ, W.: Studien an eineiigen Zwillingen. *Ztschr. f. klin. Med.*, 101: 114, 1925.
326. WERTHAM, F.: Progress in psychiatry: IV. Experimental type psychology. *Arch. Neurol. & Psychiat.*, 24: 605-611, 1930.
327. WERTHEIMER, F. I., and HASKETH, F. E.: The Significance of the Constitution in Mental Disease. *Medicine Monographs*, vol. 10. *Baltimore* (Williams & Wilkins Co.), 1926.
328. WESTPHAL, K.: Untersuchungen zur Frage der nervösen Entstehung peptischer Ulzera. *Deutsches Arch. f. klin. Med.*, 114: no. 4, 1917.
329. —: The use of indices as an auxiliary method in the establishment of physical types. *Human Biol.*, 3: 420-428, 1931.
330. —, and STRAUM, E. B.: Über den Wert der Indexberechnung bei der Körperbauforschung: II. *Ztschr. f. d. ges. Neurol. u. Psychiat.*, 130: 243-248, 1930.

331. WHEELER, W. M.: Physiognomy of insects. *QUART. REV. BIOL.*, 2: 1, 1927.
332. WIGERT, V.: Versuche zur anthropometrischen Bestimmung der Körperbautypen. *Ztschr. f. d. ges. Neurol. u. Psychiat.*, 143: 651-700, 1933.
333. YOUNG, M.: A study of rheumatic fever and asthmatic children with special reference to physical type. *J. Hyg.*, 33: 435, 1933.
334. ZWING, H.: Habitus und Lebensalter. *Ztschr. f. anag. Anat.*, 4: 255, 1919.





RECENT ADVANCES IN ANTARCTIC BIO-GEOGRAPHY

By ALTON A. LINDSEY

*Biology Department, University of Redlands, Redlands, California. Vertebrate Zoologist,
Byrd Antarctic Expedition II*

IN CONSIDERING the geographic and broad ecological relations of antarctic life, we are confronted at the start with two different practices in the delimitation of the Antarctic zone by recent authors. Since the Antarctic continent at several points extends to the north of the Antarctic circle, it is obvious that the latter cannot serve as a natural zonal boundary. The parallel 60° S. Lat., which touches no land whatever, has long been used as a convenient line between the Antarctic and sub-Antarctic zones, since the lands within this parallel are subjected to the truly continental climate of Antarctica. This is the current practice of authors dealing with terrestrial plants and animals. On the other hand, students of marine life have been impressed by the powerful effect on the distribution of organisms exerted by the hydrologically determined zones of surface water. Such authors use the term "Antarctic zone" to designate a much larger area of sea and land, namely, the whole region south of the Antarctic convergence or northern limit of cold antarctic surface water. This boundary is rather irregular, paralleling neither the continental coast nor any parallel of latitude. By roughly averaging its position around the globe, one finds the average latitude of this convergence is approximately 50° S. Also, at any given longitude the position of the convergence fluctuates considerably in latitude from time to time. The marine organisms of

the surface waters change their distributional boundaries accordingly, but the terrestrial floras and faunas do not.

Islands and archipelagos which are characterized throughout an extensive biological literature as typically sub-Antarctic are now found, according to other authors, in the Antarctic zone. Such islands situated south of the Antarctic convergence are Macquarie, South Georgia, and possibly Kerguelen; regarding these, as Rudmose Brown (1928) wrote, "the term 'sub-Antarctic' is justified rather by proximity to the Antarctic rather than by any real approximation to Antarctic conditions."

The difference between the two leading usages of the term "sub-Antarctic" is even greater than that between the definitions of "Antarctic zone." Such ambiguity in bio-geographical nomenclature may be avoided by the use of the classification of life zones herein proposed. Both concepts of the Antarctic zone mentioned above are firmly entrenched in the literature, since both are biologically valid. The names, not the concepts, are at fault. Both concepts have a valid ecological basis because of the great difference in specific heat between water and air, and the recognized distinction between macroclimate and microclimate. We must recognize the disparity between terrestrial and marine habitats in the temperature and other conditions to which organisms are actually subjected during the growing season.

All terrestrial and fresh-water plants and animals which occur south of 60° S. Lat. may be referred to the *Antarctic land province*, dominated by the continental climate of Antarctica. The South Orkney Islands, for example, located just within the boundary, support no vascular plants and no liverworts. The *sub-Antarctic land province* corresponds with Skottsberg's (1905) "*sub-Antarctic vegetation province*," including the Kerguelen district, New Zealand district, sub-Antarctic South America district, and South Georgia district. Referring to the distribution of marine organisms only, the *Antarctic marine zone* is the zone of surface water bounded on the north by the Antarctic convergence, and the surface water zone next to the northward which is bounded on the north by the sub-tropical convergence constitutes the *sub-Antarctic marine zone*.

PHYTOPLANKTON

Plankton plants constitute the organic foundation of the pelagic ecology of the sea. Diatoms are the dominant constituents of the phytoplankton of the southern ocean. Two main diatom floras exist there, a warm-water and a cold-water flora, and the two are in general separated by the sub-tropical convergence. Environmental factors greatly influence the size of the diatom frustule. According to Hendey (1937), the warm-water flora, subjected to a high hydrogen ion concentration and a limited supply of silica, phosphates, and nitrates, is characterized by thin-walled individuals with relatively large cubical capacity and low surface area, tending to approach spherical form. Although in the Antarctic and sub-Antarctic marine zones nutrient salts seldom if ever fall so low as to become a limiting factor to growth, and dissolved CO₂ and O₂ are present in high concentrations, the low temperature and decreased

sunlight do not favor large individuals. The size-temperature relation of marine plankton diatoms is thus the reverse of that of many classes of marine animals in which individuals of the same species reach a larger size in colder waters. The decreased size and heavier silicification produces a denser cell, one with a greater mass per unit volume, which necessitates development of a slender cylindrical form and bristly appendages to insure buoyancy. In some genera, the individuals probably have some control over their own buoyancy.

Hendey divides the cold-water flora into an oceanic sub-flora (forms that are constantly free-floating, normally solitary individuals) and a neritic (coastal) sub-flora. Some of the neritic forms are free-floating, but most of them are bottom-dwelling or coast-line species which form groups of many attached individuals. The predominant species obtained from sea ice are truly neritic. The characteristic ice-flora of the Antarctic seems to differ entirely from that of the Arctic not only in specific composition but even in general types of species.

A peculiar diatom population is formed upon the skin of whales in Antarctic waters only. Hart (1935) states that a readily visible diatom film indicates that the whale has been within the Antarctic zone at least one month. The truly oceanic species are entirely absent from the skin flora, the predominant types being stalked and bottom-dwelling diatoms.

Nearly all southern diatom species are tolerant of considerable environmental variation, and therefore have a very wide geographic range. However, circumpolar collections by Hart (1937) have demonstrated that one species (*Rhizosolenia curvata*) constitutes by far the best biological indicator of the southern limit of sub-antarctic surface water. This limit,

the Antarctic convergence, fluctuates considerably; but whenever it was shown hydrologically that the sub-antarctic surface water had been forced southward of its average position, this readily identified diatom was found in the plankton. Its occurrence on the Antarctic side of the convergence is a good indication that mixing is in progress or has very recently taken place, since in the changed environment provided by the mixed water the diatom reproduces by vegetative division only, and cannot long persist.

Diatoms show a striking seasonal variation in abundance in southern waters, the fewest occurring in the winter months June, July, and August. A noticeable increase takes place in October, and during November most southern diatom genera reach their great maxima in the northern part of the antarctic marine zone, and in the southern part of the sub-antarctic marine zone to a less extent.

The most pronounced biological feature of cold seas is the amazing wealth of phytoplankton, as regards individuals rather than species. The numbers of some species often run into millions in a single haul. The explanation usually given is the high concentration of nutrients and gases in these waters. Experiments by Loeb (1908) on larval sea-urchins demonstrated a striking differential, at low temperatures, between the longevity of the individual and the time it requires to attain reproductive maturity. By lowering the temperature 1° C. the duration of life is about doubled, but the period of development is lengthened only very slightly. The organism's reproductive capacity is thus vastly increased, and very many more generations exist simultaneously at the lower temperature. Whether or not this principle is applicable to multicellular zooplankton generally, it cannot be extended to unicellular phytoplankton

organisms, and it is the latter group which is chiefly responsible, both directly and indirectly, for the teeming life of polar waters. These plants reproduce both sexually and asexually, and in either method the parental protoplasm is used up. The individual's life span coincides with the generation which it represents, therefore no differential can exist between the pre-reproductive period and individual longevity.

There have been attempts to explain the inverse relation of temperature to plankton production, as well as the apparent effect of melting ice in stimulating production, by reference to the "polymerization" theory of water structure. Barnes (1932), Harvey (1933), and Barnes and Jahn (1933) reported that recently melted water stimulated growth beyond that occurring in ordinary water at equivalent temperatures. This effect would depend on a lag in the attainment of equilibrium in the changed organization of water after a temperature change. Such a lag has not been convincingly demonstrated by physical methods. Moreover, recent work on the internal structure of water by Bernal and Fowler (1933) and Morgan and Warren (1938) makes it difficult to accept the scanty biological evidence for this lag. The problem of the physiological effect of the thermal history of water is reviewed by Barnes (1937). A clear non-technical summary of the theoretical structure of water is presented by Gibson (1938).

With the lowering of the temperature of sea water, its density increases right to the freezing point (about -1.9° C.). Unless the above-mentioned lag can be proven, it would seem impossible to separate experimentally the effect on marine plankton of temperature, density, and molecular orientation of water.

LICHENS

The southernmost known plants are four species of lichens found at the Queen Maud Range in 1934 at 86° 03' S. Lat., within 237 geographical miles of the pole. Only 32 miles farther north the same party collected six lichen species, and one imperfect fungus. All seven lichen species represented are new to science; four of them are apparently restricted to this Queen Maud locality, but the other three were found also by Siple's (1938) sledging party of the second Byrd Antarctic Expedition. In Marie Byrd Land and King Edward VII Land this party encountered a truly surprising amount of plant life. From the collection, seventy-seven additional new species of lichens were described by Dodge and Baker (1938). The lichens now known from the Antarctic land province number 293 species.

It is significant that all eighty-nine lichen species found by this expedition are endemic to this province. Moreover, Dodge and Baker regard supposed identity of Antarctic species with northern ones as based on uncritical taxonomic work, which would mean that about forty new unnamed species may exist in material already collected.

Although the paucity of endemic genera opposes the view that Antarctic lichens represent an ancient pre-glacial flora, evidence from the composition of the lichen body favors this conclusion. The algae found associated with the fungi in all lichens from continental Antarctica are green algae resembling the familiar *Protococcus*. Such lichens form a much older plant group than those with blue-green algae as symbionts. It is clear that blue-greens can withstand antarctic conditions, since algae of this group were found living independently in the same locality. It is therefore considered pos-

sible that an antarctic lichen flora has survived the present glacial period on the continent, the more recently evolved lichens which contain blue-green algae having failed to penetrate there as yet.

Noteworthy differences are found between temperate zone lichens and Antarctic species of the same genera. In the latter the algal cells are much less abundant, and often occur more or less scattered throughout the medulla rather than organized in a definite layer below the cortex. Also the whole thallus, according to Siple (1938) is greatly reduced in proportion to the fruiting structures, and the plants are usually dark colored, resulting in readier absorption of the sun's heat.

Evidence from the work of Stuckey and Curtis (1938) and others on higher plants indicates that freezing temperatures cause the death of plant tissues by mechanical injury resulting from ice formation within the cytoplasm, rather than by desiccation or other causes. Anything that will decrease the amount of free water within the cell at the time of freezing seems to lessen the possibilities of ice formation. Physiological studies of Antarctic lichens in their resistance to freezing would be of much interest. Pending such work, we may speculate on their remarkable resistance by analogy with other plants. It is known that only free water freezes in plants; bound water can not form ice. When lichens are not snow-covered, the very low absolute humidity of cold antarctic winds may cause rather thorough drying of the plants, plasmolyzing the cells and reducing the free water to a minimum. Lichens contain large amounts of lichenin and other dextrosans. These colloidal hemicelluloses swell readily in water, so that by imbibing and binding the free water and thus greatly increasing the osmotic concentration in the vacuole

these substances may prevent the formation of ice within the cells.

As evidence of the extreme slowness of lichen growth at Graham Land, Bertram (1938) points out that the lichens on the stones of a cairn built by Charcot in 1909 still retained their original orientation in 1935.

Much more collecting must be carried on by trail parties before a satisfactory understanding of plant distribution on the Antarctic continent can be gained. In the past nearly all sledging parties have missed all but the most conspicuous plants. Most lichens masquerade as minute crumbs of dirt on rocks. Many tiny forms are bud-like in shape, resembling succulents; others, almost microscopic in size, are wedged in the intercrystal cracks of rocks. The fact that most of the mountains Siple studied had species apparently restricted to them strongly suggests that many more new species await discovery by careful search of the hundreds of coastal peaks as yet unvisited. Even the Queen Maud Range fringing the polar plateau, practically untouched by lichen-conscious sledgers, may be expected to yield new species and extension of range of known forms.

BRYOPHYTES

Seventy-three species of mosses occur in the Antarctic land province, thirty of them being endemic there. Mosses have been found only to 78° S. Lat., and at this latitude only in South Victoria Land. Graham Land supports a much richer bryophyte flora. Between these regions, in Marie Byrd Land, five species have recently been collected. Two of these extend to both Graham Land and South Victoria Land, but the dominant moss of Marie Byrd Land is found in Graham Land and not South Victoria Land. The

two remaining mosses were described by Bartram (1938) as new species.

The Argentine Islands off Graham Land constitute the richest area botanically in the Antarctic land province. On sheltered inshore islands at about 68° S. Lat., Bertram (1938) studied patches of a closed moss association up to an acre in extent which had produced a peat as much as three feet in thickness.

Six species of hepatics grow south of the sixtieth parallel.

VASCULAR PLANTS

The New Zealand Sub-Antarctic Islands possess 88 genera of vascular plants, 56 of which are represented in Fuegia also. Such striking floristic affinities between sub-Antarctic America and the New Zealand region have led botanists to support the idea of a former Antarctic center of plant distribution. They picture an early Tertiary Antarctic flora pushing northward along both sides of the Pacific, utilizing on the east a land bridge or chain of islands between Graham Land and Fuegia, and on the west a hypothetical "Greater New Zealand" which approached Antarctica sufficiently for ready transfer. Subsequent glacierization destroyed all the higher vegetation of the continent, and that of the sub-Antarctic land province except for a few species. The sources of repopulation were Fuegia and New Zealand. The latter supplied the major part of the flora now found in the New Zealand Sub-Antarctic Islands, which in turn largely restocked Macquarie Island. About 18 species are to-day more or less circumpolar in the sub-Antarctic land province, and three of these are truly circumpolar, occurring on almost all the sub-Antarctic islands. Only two flowering plants grow within the Antarctic Circle (or even south of 60° S. Lat.),

whereas Hooker (1861) listed 762 species within the Arctic Circle.

Skottsberg (1936) has called attention to the striking distribution of a few genera from the original Antarctic center which are now represented by geographically isolated species in Polynesia. The affinities of such species in Hawaii are not with south-western Pacific plants, but with those of sub-Antarctic and temperate South America.

The plant geography of the south-western Pacific in relation to the theory of continental drift is discussed by Diels (1936), who finds several genera and species of relatively recent Antarctic origin occurring in the south-eastern part of Australia. A more important element in Australia's flora is of much older standing there, comprising ancient types lacking Antarctic affinities. A third element is so related to Malaysia that interchange from early times is apparent. These facts are all contrary to the principal assumption of Wegener's hypothesis: that Australia drifted to the north quite recently and approached south-eastern Asia.

MARINE INVERTEBRATES

The main features of Antarctic zooplankton are summarized by Hardy and Gunther (1935) as follows: (1) the small number of species inhabiting the surface layer, i.e., the top 150 meters, the species which do so being very prolific; (2) the lack of pelagic larval stages of benthic animals; (3) the absence of a daylight surface fauna; (4) the importance of vertical migration.

The latter point requires some explanation. Since plankton organisms are unable to control their distribution by actively swimming against ocean currents, how do species characterizing different regions maintain their normal ranges in

spite of constantly changing waters? During two years on the ship *Discovery II*, Mackintosh (1937) investigated this question in the eastern Pacific. He learned that the three most important zooplankton species perform an annual vertical migration, drifting northward in the surface water in summer, and descending to very deep southward-flowing water in winter. The vertical range is from 400 to 600 meters and the horizontal range some hundreds of miles. This is held to be the normal and general means by which ranges are maintained in the higher latitudes of the southern ocean.

Ecologically the most important animal in the Antarctic marine zone is an opossum shrimp, *Euphausia superba*. Its food consists very largely if not entirely of diatoms and other plankton plants. In contrast to a one-year period in other euphausians whose life history is known, the developmental period in this species is two years. The wide range of time within which older forms are found is important, Fraser (1936) points out, in insuring a constant supply of food for whale-bone whales in the south. Continued abundance of the species in the far south is attributed to a rotary movement resulting from the concentration of the earlier developmental stages in the southward-flowing warm deep water, and that of the later stages in the northward-flowing Antarctic surface water. Thus the stock of adolescents at the edge of the fast ice is constantly replenished.

The Antarctic and sub-Antarctic Echinoderm fauna is extremely rich, far exceeding that of the Arctic and sub-Arctic regions. We are still far from a satisfactory knowledge of the species, much less their biology and distribution. Investigation of the almost unknown ocean floor of the far southern Pacific is particularly needed.

Burton (1932) refers to the belief among geologists that the growth of sponges is most prolific in warm seas, and that a deposit rich in sponge remains must therefore have been laid down in a warm sea. He proves by the present abundance of living sponges in Antarctic waters that this is not the case in recent times. Sponges are at least as abundant, and probably more so, in the Antarctic as in the West Indies, Australia, or the Indian Ocean. Even more important geologically is the fact that sponges of colder waters are almost exclusively siliceous and hence favorable for fossil formation, while the soft spongin material of a large percentage of warm-sea sponges is unlikely to be preserved.

That sponges reached their maximum development in the Cretaceous period is another belief for which evidence is lacking. Neither in the complexity of the skeleton, the size of the spicules, the size of individual sponges, nor in the diversity of species did the Cretaceous fauna surpass the development of present Antarctic sponges or those of any other quarter of the globe.

Turning to the unicellular forms, one finds the Antarctic Foraminifera limited in both genera and species and primitive in character. Earland (1934) stresses the similarity of this fauna to that of the deep sea in all latitudes. Many species in the Antarctic are truly cosmopolitan; others are closely allied to deep-sea forms, having probably migrated from the depths of the adjacent oceans.

After reviewing the evidence bearing on the theory of bipolarity, Murphy (1928) concludes that the theory can no longer be accepted in its broad and naïve sense. He raises the question whether the inconclusive data may not support equally well the converse theory of an earlier universal cold sea rather than a

universal warm one that has since cooled at the poles.

TERRESTRIAL INVERTEBRATES

The largest permanent inhabitant of the Antarctic land province is the wingless fly *Belgica*, about five millimeters in length. Several protozoans, sixteen species of rotifers and the same number of tardigrades, two fresh-water crustaceans, mites, and at least 18 species of insects comprise the known fauna. The insect orders represented are the Collembola, Corrodentia, Mallophaga, Anoplura, and Diptera.

A sledging party sent by Byrd into Marie Byrd Land found that the distinct pink color of a mucky pond bottom was due to a profusion of brilliantly red rotifers. Upon thawing of ice in which tardigrades and rotifers had been frozen, probably for some years, these creatures suddenly resumed activity.

The recent British Graham Land Expedition reports (Bertram, 1938) the first species of copepod (water flea) discovered in Antarctica.

Davies (1935) maintains that the Collembola, being primitively wingless insects, constitute better material for the study of geographic distribution than any other insect order, because migration by flight is impossible and the delicate integument makes it very unlikely that they could be carried any appreciable distance by the sea. There are at least 11 species in the Antarctic land province, representing 9 genera. The genus *Cryptopygus* includes only three species; one is Fuegian, a second is Antarctic and sub-Antarctic in the Scotia Arc, and a new species has been described from New Zealand. This genus thus furnishes probably valid evidence of former land connections. However, since Collembola are usually associated with penguin rookeries

and beaches frequented by penguins, it is at least conceivable that the insects may be transported beneath the waterproof feather coat of these widely wandering birds.

VERTEBRATES

Five families of Antarctic and sub-Antarctic fishes are important in the Patagonian region, together constituting one of three categories of Patagonian coastal fishes (Norman, 1937).^a One species of the family Nototheniidae ranges from Graham Land northward up the coast of Argentina to the Rio Plata. However, the characteristic Antarctic genera, *Pleuragramma* and *Trematomus*, do not reach Patagonia.

In defining the austral fish regions, Regan (1914) added confusion to zonal concepts by adoption of the mean annual surface isotherm of 6° C. as the northern limit of the Antarctic zone, thus including the Kerguelen district (the Kerguelen, Prince Edward, Crozet, Marion, and Heard Island groups) within this zone. Norman (1937) has shown that the dissimilarity between the Patagonian region and the Kerguelen district is less marked than Regan believed, and has pointed out several features which the areas have in common. It should be remembered that most islands of the Kerguelen district are well to the north of the Antarctic convergence, and all of them are a considerable distance north of the sixtieth parallel. The Kerguelen district should be considered sub-Antarctic not only regarding the land biota, but those of its islands lying between the Antarctic and sub-tropical convergences must also be washed by waters of the *sub-Antarctic* marine zone.

Although Macquarie Island lies south of the surface isotherm of 6° C., Regan admits it to the sub-Antarctic zone on

evidence from fish distribution. This island is decidedly sub-Antarctic in its terrestrial aspects, although it lies a little to the south of the Antarctic convergence. Since the 6° C. isotherm as the northward boundary of the zone of Antarctic coastal fishes breaks down in the important instances of Macquarie Island and the Kerguelen district, it is unsatisfactory as a zonal boundary.

Murphy (1936) has amassed abundant evidence in support of the thesis that ecologically oceanic birds are primarily aquatic rather than aerial organisms, and that their distribution is controlled by oceanographic factors. The birds of the southern oceans, therefore, can be understood only in relation to the zones of surface water. They must be considered, together with other marine organisms, as subject to the zonal bounds of the convergences rather than to the control of the climate of continental Antarctica, and consequently belong in the marine zones rather than the land provinces.

Few Antarctic birds are even reasonably well known from the standpoint of detailed life-history and behavior. The Adelie Penguin remains the best known scientifically as well as popularly. The four birds that breed farthest south are the Emperor Penguin, Adelie Penguin, MacCormack's Skua, and Snow Petrel. The Skua wanders farthest inland; the southernmost record was an individual that visited Captain Scott during his last journey, at a point on the polar plateau 560 geographical miles from the sea and only 160 miles from the pole, at an elevation of 9,980 feet. Murphy lists fifteen birds as typical of the Antarctic (marine) zone: four penguins, two albatrosses, eight petrels, and one skua. A Snow Petrel rookery reported by Siple and Lindsey (1937) from King Edward VII Land advanced the known breeding range

of this species 400 geographical miles to the south.

Murphy (1936) casts serious doubt on the oft-cited 22,000 mile annual migration of the Arctic Tern, which is supposed to regularly cross the Antarctic Circle and sometimes reach 74° S. Lat. A few specimens have been taken near the Antarctic Circle in the Weddell Sea and Pacific, but the normal winter range appears to be the Pacific off the coasts of Peru and Chile, and similar latitudes in the Atlantic. Most alleged Antarctic occurrences of the Arctic Tern are based on sight records, which are valueless because this bird is not distinguishable in the field from the Antarctic Tern (*Sterna vittata*). The suggestion that the latter bird is masquerading generally in ornithological literature as the Arctic Tern may well prove correct when adequate bird collections from Antarctic waters have ultimately been built up.

Four species of seals have a circumpolar distribution in the Antarctic marine zone. The Ross seal is so rare that probably fewer than fifty individuals have ever been seen. The sea leopard is a solitary wanderer that feeds largely on penguins. In this species the females attain a larger size than the males, which seems to be true, although to a less degree, of the Weddell seal also. The crab-eater is a slender, agile seal inhabiting the pack ice chiefly. Lindsey (1938) found that a female of this species when barely two years old may give birth to its first young. In locomotion on snow-covered sea ice, crab-eaters about four months old show

remarkable speed and endurance. Often a man running at top speed cannot keep pace with the seal as it strikes the hard-packed snow with tremendous blows of the hind flippers held together vertically like a caudal fin.

Of the four Antarctic seals, only the Weddell is well known as regards habits and life history (Lindsey, 1937). When a female has just turned three years of age her first pup may be born. The average pup is 34 days old when the full set of teeth appears, and it depends on the mother's milk for 48 days after birth. This offers a marked contrast to the crab-eater seal, which has been reported to possess perfectly functional teeth at birth and to separate from the mother two or three days after birth. Young Weddell seals average 64 pounds at birth, and, feeding exclusively on mother's milk, several averaged seven pounds gain in weight *daily* for seven consecutive days or longer. This is the southernmost mammal, and is found throughout the year at the extreme southern limits of its range. In winter its layer of blubber reaches four inches in thickness. The animal remains at this season beneath the new ice, through which it maintains breathing holes by sawing ice by means of the strong canine teeth. In this process the head is swung from side to side with the mouth opened to a 150 degree angle. Feeding on fish secured in the watery darkness beneath eight or ten feet of ice, this seal, alone among mammals, withstands the rigors of the four sunless months at 78° S. Lat.

LIST OF LITERATURE

- BARNES, T. C. 1932. The physiological effect of trihydrol in water. *Proc. Nat. Acad. Sci.*, 18: 136-137.
- , and T. L. JAHN. 1933. The effect of ice and steam water on *Euglena*. *Proc. Nat. Acad. Sci.*, 19: 638-640.
- BARNES, T. C. 1937. Textbook of General Physiology. Philadelphia. Pp. 133-137.
- BARTRAM, E. B. 1938. Mosses. Second Byrd Ant. Expd. Botany III. *Ann. Missouri Bot. Gard.*, 25: 719-724.

- BERNAL, J. D., and R. H. FOWLER. 1933. Theory of water and ionic solution, with particular reference to H and OH ions. *Jour. Chem. Phys.*, 1, pp. 515-548.
- BERTRAM, G. C. L. 1938. Plants and seals. Notes on the scientific work of the British Graham Land Expedition, 1934-37. *Geog. Jour.*, 91: no. 6, 523-526.
- BROWN, R. N. Rudmose. 1928. Antarctic and sub-Antarctic plant life and some of its problems. Problems of polar research. *Spec. Publ. Am. Geog. Soc.*, no. 7, pp. 343-352.
- BURTON, M. 1932. Sponges. *Discovery Reports*, 6: 237-392.
- DAVIES, W. M. 1935. Collembola. *Discovery Reports*, 10: 379-380.
- DIELS, L. 1936. The genetic phytogeography of the southwestern Pacific area, with particular reference to Australia. In *Essays in Geobotany in Honor of William Albert Setchell*. Berkeley. Pp. 189-194.
- DODGE, C. W., and G. E. BAKER. 1938. Lichens and lichen parasites. Second Byrd Ant. Expd. Botany II. *Ann. Missouri Bot. Gard.*, 25: 515-718.
- EARLAND, A. 1934. Foraminifera. *Discovery Reports*, 10: 1-208.
- FRASER, F. C. 1936. On the development and distribution of the young stages of krill (*Euphausia superba*). *Discovery Reports*, 14: 1-192.
- GIBSON, R. E. 1938. The nature of solutions and their behavior under high pressures. *Scientific Monthly*, 46: 103-119.
- HARDY, A. C., and E. R. GUNTHER. 1935. The plankton of the South Georgia whaling grounds and adjacent waters, 1926-1927. *Discovery Reports*, 11: 1-456.
- HART, T. J. 1935. On the diatoms of the skin film of whales, and their possible bearing on problems of whale movements. *Discovery Reports*, 10: 247-282.
- . 1937. *Rhizosolenia curvata* Zacharias, an indicator species in the southern ocean. *Discovery Reports*, 16: 413-446.
- HARVEY, H. W. 1933. On the rate of diatom growth. *Jour. Marine Biol. Assoc.*, 19: 253-275.
- HENDY, N. I. 1937. The plankton diatoms of the southern seas. *Discovery Reports*, 16: 151-364.
- HOOKE, J. D. 1861. The distribution of Arctic plants. *Trans. Linn. Soc.*, 23: 251-348.
- LINDSEY, A. A. 1937. The Weddell seal in the Bay of Whales, Antarctica. *Jour. Mamm.*, 18: 127-144.
- . 1938. Notes on the crab-eater seal. *Jour. Mamm.*, 19: 456-461.
- LOEB, J. 1908. Über den Temperaturkoeffizienten für die Lebensdauer kaltblütiger Thiere und über die Ursache des natürlichen Todes. *Pflügers Archiv für die Gesamte Physiol.*, 124: 411-426.
- MACKINTOSH, N. A. 1937. The seasonal circulation of the Antarctic macroplankton. *Discovery Reports*, 16: 365-412.
- MORGAN, J., and B. E. WARREN. 1938. X-ray analysis of the structure of water. *Jour. Chem. Phys.*, 6, pp. 666-673.
- MURPHY, R. C. 1928. Antarctic zoogeography and some of its problems. Problems of Polar Research. *Spec. Publ. Am. Geog. Soc.*, no. 7, pp. 355-379.
- . 1936. Oceanic Birds of South America. Am. Mus. Nat. Hist., New York.
- NORMAN, J. R. 1937. Coast fishes. Part 2. The Patagonian region. *Discovery Reports*, 16: 1-150.
- REGAN, C. T. 1914. Fishes. *British Ant. ("Terra Nova") Expd. Nat. Hist. Repts., Zoology*, 1: 1-54.
- SIPLE, P. A. 1938. Ecology and geographic distribution. Second Byrd Ant. Expd. Botany I, *Ann. Missouri Bot. Gard.*, 25: 467-514.
- , and A. A. LINDSEY. 1937. Ornithology of the second Byrd Antarctic Expedition. *The Auk*, 54: 147-159.
- SKOTTSBERG, C. 1905. Some remarks upon the geographical distribution of vegetation in the colder southern hemisphere. *Ymer*, 25: 402-427.
- . 1936. Antarctic plants in Polynesia. In *Essays in Geobotany in Honor of William Albert Setchell*. Berkeley. Pp. 291-310.
- STUCKEY, I. H., and O. F. CURTIS. 1938. Ice formation and the death of plant cells by freezing. *Plant Physiology*, 13: 815-833.



NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will frequently appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to Dr. Raymond Pearl, Editor of THE QUARTERLY REVIEW OF BIOLOGY, 1901 East Madison Street, Baltimore, Maryland, U. S. A.

BRIEF NOTICES

EVOLUTION

THE NEW SYSTEMATICS.

Edited by Julian Huxley. Oxford University Press, New York; The Clarendon Press, Oxford. \$6.00. 8½ x 5½; viii + 583; 1940.

This is a book that systematic biology has been waiting for ever since the doctrine of evolution received general acceptance. Previous to that time taxonomic systems were not based on real relationships, for no one believed that any real relationship existed. But with the coming of evolution the need for a phylogenetic classification has become obvious. Yet the old time taxonomic systems have been strangely little disturbed by the new light that has been shed on phylogenetic relationships by modern research.

One reason for this is the natural reticence of any investigator to set up a system of taxonomy that may have to be discarded next week because another observer has demonstrated a new truth of nature inconsistent with it. In the old days when all systems were equally logical, and the only criterion for value was convenience there was no objection to every systematist having his own peculiar systematics, as the differences among the taxonomies of Linnaeus, DuRoi, and Lamarck testify. Another reason is that most modern biologists are specialists in a limited taxonomic field, in which those modifications relied upon

for classificatory discrimination appear (to them) much larger than equivalent modifications in other fields.

The present work is a symposium by twenty-two European biologists and one American, all of whom endeavor to record their beliefs as to what shall be the guiding principles of the new taxonomy. That they consulted each other is clear from the numerous references in each essay to the other essays in the volume, but they have not arrived at any agreement among themselves as to what constitutes a taxonomic group, or how taxonomic groups arrive. For instance, one of the collaborators, Lancelot Hogben, has contributed a very thought-provoking chapter in which, with characteristic iconoclasm, he reproves Darwin for not having named his work "The Origins of Species." The process of speciation comes about as the result of the interaction of numerous factors, and if the combination of factors occurs more than once a species may have a multiple origin.

This point is brought up by W. J. Arkell and J. A. Moy-Thomas who refer to the genus *Gryphaea* which occurs in the Cretaceous and the Tertiary, in three different horizons which alternate with others in which it is absent. But these authors make it clear that while the genus has thus originated several times it has only had one origin—it is a modified *Ostrea*, and this latter genus has retained

as a generic characteristic the ability to produce forms resembling *Gryphaea* even to the present day, for there is a recent *Ostrea* in the collection of Stanford University that no paleontologist would hesitate to assign to *Gryphaea* if it had been recovered from a Tertiary horizon.

The laboratory worker who is privileged to see how variation takes place under controlled conditions is likely to have ideas of his own, and the present reviewer finds it difficult to refrain from interspersing his own thoughts into this review. Perhaps that has been one object of the collaborators who have produced the book—to stimulate thought. It is unbelievable that any one could read such a work and not emerge from the experience with his mind clarified and stimulated for further research. The ample bibliographies at the end of each chapter are most helpful, as is also the index which covers seventeen pages of fine print.

The reviewer finds it impossible to compare the essays in this work on the basis of relative merit. They are all good. About all he feels justified in saying is that he found those by C. Diver and J. R. De Beer the most interesting, that by H. J. Muller the most informative, and that by J. S. L. Gilmour likely to have the widest appeal. But they are all good and well worthy of inclusion in such a symposium.



THE MATERIAL BASIS OF EVOLUTION.

By Richard Goldschmidt. Yale University Press, New Haven; Oxford University Press, London. \$5.00. 9 x 6; xi + 436; 1940.

The Silliman Foundation at Yale University was established for the purpose of organizing an annual course of lectures designed "to illustrate the presence and providence, the wisdom and goodness of God, as manifested in the natural and moral world." It was further directed that each annual course should be made the basis of a volume to form part of the series constituting a memorial to Mrs. Silliman. The present volume is the published form of the 1939 Silliman lectures.

The first point in the author's discussion of the problem of evolution is an attack on the neo-Darwinian thesis; a thesis which holds to the idea that abrupt changes, or mutations of the hereditary determiners (the genes) are the starting point for evolution; and that the accumulation of mutations, their isolation and selection in the new variants—which are themselves capable of transmitting the new characters, as well as of producing new ones by the same process—account for all evolutionary divergencies. Goldschmidt's criticism of this theory is that it must accept the fact that somehow new genes are formed, since it is unlikely that man and amoeba are connected by mutations of the same original genes. He believes that a sounder thesis of evolution can be based on the combined workings of what he has termed micro- and macro-evolution. Micro-evolution within the species is the process of the accumulation, selection, and adaptation of minute (micro) mutations. Micro-evolution produces changes which *never transcend* the confines of the species, hence the typical products of micro-evolution—the geographic races—can never be considered incipient species. On the other hand, species, genera, families, and the higher categories of classification originate in single macro-evolutionary steps as completely new genetic systems.

The mass of well-organized, analyzed and synthesized research work presented in this volume should be an inspiration to any college student, who, by the way, will find here a new and stimulating thesis upon which to build his knowledge of evolution, and one which should be studied carefully in the light of the neo-Darwinian theory, as well as the theory of the gene.

The text is beautifully illustrated, completely indexed, and has a bibliography of some 400 titles.



MAN KIND IN THE MAKING.

By M. Cashcart Borer. Frederick Warne and Co., London and New York. \$1.50. 7½ x 5½; [6] + 152 + 8 plates; 1939.

This most interesting volume is an accu-

rate and fascinating chronicle of the past history of *Homo sapiens*, written by one who has a knack, not only of being informative, but also of encouraging a desire for further information among his readers. The book starts out with the beginning of things and discusses in order: the ancestors of man, the great ice age and the men of that era, the men who came after the ice age, the old stone age, the middle stone age, and concludes with an exhilarating report on the neolithic period. There is neither an index nor a bibliography, but the book is well illustrated with beautiful color plates and line drawings.



GENETICS

MAMMALIAN GENETICS.

By William E. Castle. *Harvard University Press, Cambridge; Oxford University Press, London.* \$2.00. 9 x 6. viii + 169 + 40 plates; 1940.

Mammalian Genetics is intended for use in introductory courses in genetics—preferably the Senior High School or Junior College level. The material of the text is organized in conformity with the more recent and so-called better pedagogical trend of leading from the familiar to the unfamiliar; from the known to the unknown; and from the general to the specific.

The idea of inducting college freshmen into genetics via Mammalia (since the freshman himself is a mammal, and presumably will want to know something of his own inheritance as well as that of our domestic animals) is a noble one, but in view of the considerations of time, expense, and simplicity of form, this reviewer still believes that *Drosophila* provides the best route for elementary work in genetics. Even though a student has seen more, and is more familiar with rabbits, cows, and mice than *Drosophila*, it is almost a certainty that he will know little or no more of the genetics of the mammals than of *Drosophila*; and it is equally a certainty that he can learn, by experimentation, the genetics of the latter much more quickly than that of the former.

The early chapters of the book present

a very elementary treatment of the laws of Mendelian inheritance, linkage, and crossing-over, as demonstrated by the guinea pig, rabbit, rat, and mouse. *Drosophila* is used to demonstrate sex-linked inheritance. The later chapters deal with the inheritance of blood groups in rabbits and man, and the more common mutations among our domestic animals.

A short bibliography is appended to each chapter of the text, and there is a short table of contents and an index.



BREEDING AND MANAGEMENT OF LIVE STOCK (*Cattle, Horses and Pigs*). *Together with a Section on Pig Farming. Second Revised Edition.*

By A. W. G. Lipscomb. *Section on Pig Farming written in association with F. Discombe. Whitcombe and Tombs, Wellington, London, Melbourne and Sydney.* 7s. 6d. net. 7½ x 5; 362; 1940.

The scientific breeding and care of live stock is one answer to the growing demand for domestic animal products by the ever-increasing world population. To meet the need for a text which would outline the most recent advances in this phase of agriculture, Lipscomb compiled this volume. It contains a wealth of information for farmers, students of agriculture, and anyone else who is interested in the status and welfare of the domestic animals. The subject of sheep farming, which has been adequately treated in other volumes, is not included. The statistics and records, which in this edition have been completely brought up to date, are drawn largely from Australian and New Zealand sources, but there is much material that is applicable to animal husbandry in any corner of the globe. The text is supplied with a useful gestation table for mares, cows, ewes, and sows; a complete index; and numerous well-chosen illustrations.



GENERAL BIOLOGY

WHERE IS THE — COLLECTION? *An account of the various Natural History Collections which have come under the notice of the compiler between 1880 and 1939.*

Compiled by Charles Davies Sherborn. The University Press, Cambridge; The Macmillan Co., New York. 90 cents. 8½ x 5½; 149; 1940 (paper).

Very few natural history collections survive the original collector. Either they are purchased by dealers who break them up for sale in small lots or they lose their identity by being absorbed by larger collections in museums. The difficulty of tracing types is manifest.

The author of the present work has compiled all the available data concerning those collections that have so disappeared during the past sixty years. One would think that a catalog of such nature would be extremely dry reading, yet those who read between the lines will find elements of both pathos and humor. For instance in it we can read of John Phillips who took his fossils to London, where they were stolen the first night by burglars, who mistook them for plate, and who, on learning of their error, threw the whole collection into the Thames from Blackfriar's Bridge; also of Charles Ottley Groom, Duke of Mantua and Monteferrat, Prince of Mantua and of the House of David, who was a notorious rogue and thief and who tried to kill Thomas Davies by dropping a boulder upon him from a high ladder in Tennant's shop in the Strand.

The work is not infallible—it puts Isaac Lea's collection of *Unionidae* in the American Museum in New York instead of the National Museum in Washington. And of course it makes no pretension of completeness—the magnitude of such a task would preclude its achievement.



LABORATORY MANUAL OF GENERAL BIOLOGY. I. Botany. II. Invertebrate Zoology. III. Vertebrate Zoology. Fourth Edition.

By John G. Arnold, Jr., and Timothy L. Duggan. C. V. Mosby Co., St. Louis, Mo. \$1.50. 10½ x 7½; 275; 1940 (paper).

LABORATORY DIRECTIONS FOR GENERAL BIOLOGY. Third Edition.

By Arthur W. Haupt. McGraw-Hill Book Co., New York and London. \$1.00. 9 x 6; ix + 65; 1940.

The first of these manuals, on loose sheets,

is based on work covered in a general biology course at Loyola University of the South, New Orleans. The second covers the general biology course at the University of California, Los Angeles. Both are designed to supplement lectures and are arranged in the form of exercises. The first guide, which covers a more extensive course than the second, is intended to acquaint the student with the external and internal structure of a large number of plant and animal types; the second, which is arranged for a class meeting twice a week in one semester, tends to emphasize, in a general way, the underlying principles of the subject.



DOWN TO EARTH. A Naturalist Looks About.

By Alan Devoe. Illustrated by Gertrude M. Bradley and D. F. L. Bradley. Coward-McCann, Inc., New York. \$2.50. 8 x 5½; x + 228; 1940.

A collection of brief essays such as most newspaper columnists affect, but from which they differ, chiefly in being more meritorious. They are excellent propaganda for sanity in living. Unfortunately, only a comparatively small proportion of the population is likely to read this book at all, and of these the reviewer fears that but few will undergo a change of conviction as a result. For every citizen like Mr. Devoe there may be several thousand "brave men of Brielle" and it is the latter who get into politics, who mold public opinion and who direct national policy. Is it surprising that the times seem out of joint?

The reviewer would like to see this book used as course reading in the secondary schools of the nation. It would be a great improvement over the anaemic imitations of natural history that served his generation.



VERITÀ BIOLOGICHE NEL PENSIERO DI SCHOPENHAUER.

By Mario F. Canella. Nicola Zanichelli Editore, Bologna. L. 5. 9½ x 6½; 16; 1938 (paper).

In this pamphlet the author argues that

there is much in the philosophical works of Schopenhauer—much more than in Plato's idealism and Kant's criticism—of fundamental interest to biologists, particularly in his concepts concerning the "will to live." In fact he concludes that the "philosophic system of Schopenhauer is the only one which can lead him [the biologist] 'as far as the solid ground of reality.'"

This is a reprint from the *Fünfundzwanzigstes Jahrbuch der Schopenhauer-Gesellschaft* (Carl Winter, Heidelberg) and the *Rivista di Psicologia*, Anno 34, Fasc. 1, both published in 1938.



BIOLOGICAL SURVEY OF THE CONNECTICUT WATERSHED. Survey Report No. 4.

By Herbert E. Warfel. State of New Hampshire, Department of Fish and Game, Concord. \$1.00. 12 x 9 $\frac{1}{8}$; 256 + 3 maps; 1939 (paper).

This fine report of the New Hampshire Biological Survey is a compilation of the data collected during the summer of 1939 and is dedicated to the memory of Earl E. Hoover (1911-1939). It is the fourth and final report of a series, the first three of which were contributed by Hoover. The report includes stocking records and policies for the streams and lakes (data arranged on master sheets, 50 pages for streams, 25 pages for lakes), geology, physical and chemical data, description of fishes, plankton, amphibians and reptiles, amphibian larvae, and freshwater shells, with locality charts, etc. Also included are many illustrations, plates, and charts, and three large contour maps in a folder attached to the back cover.



THE AIR AND ITS MYSTERIES.

By C. M. Bosley. American Edition Arranged by Hanor A. Webb. With a Foreword by Sir Richard Gregory. D. Appleton-Century Co., New York and London. \$3.00. 8 x 5 $\frac{1}{2}$; xv + 302; 1940.

To the amateur weather forecaster and others with a casual curiosity about the atmosphere this book will prove instructive. Much of the material, however, is

written in an overly simple style, and the facts and principles given are well known to anyone with a moderate understanding of physics. The early pages deal with the composition and pressure of the air and the tricks of the wind. Additional facts are given concerning clouds, precipitation, climate, and weather forecasting. Sound and light are likewise discussed, while the final chapters are devoted to the importance of weather conditions and the stratosphere in aviation and radio transmission. Numerous diagrams accompany the text and there is an adequate index.



BIOLOGICAL SYMPOSIA.

Edited by Jaques Cattell. With a Foreword by Albert F. Blakeslee. The Jaques Cattell Press, Lancaster, Pa. \$2.50. 9 $\frac{1}{8}$ x 6 $\frac{1}{2}$; vii + 238; 1940.

Containing papers by many of the leading American men of science, the material embodied herein is divided into three parts: the cell theory, mating types and their interactions in the ciliate infusoria, the chromosome structure. The various papers were originally presented at the 1938 meeting of the American Association for the Advancement of Science, in Richmond, Va., and are here brought together in permanent form. They comprise a related series of observations on an important theme. Each paper has its individual bibliography but there is no index.



FUNDAMENTALS OF BIOLOGY. Third Edition.

By Arthur W. Haupt. McGraw-Hill Book Co., New York and London. \$3.00. 9 x 6; xii + 443; 1940.

The third edition of this book follows the same conservative presentation as is found in the second edition (Q.R.B., Vol. 8, No. 2, 1932). Much new material relating to the human body and to the subject of immunity to disease has been added. Chapters on vitamins and hormones have been greatly expanded. There are also 80 new cuts.

HUMAN BIOLOGY

THE NATIVE RACES OF ASIA AND EUROPE. *Anthologia Anthropologica. A Copious Selection of Passages for the Study of Social Anthropology from the Manuscript Notebooks of Sir James George Frazer.*

Arranged and Edited by Robert A. Downie.

Percy Lund Humphries and Co., London.

35 s. 11 x 8½; vi + 399; 1939.

THE NATIVE RACES OF AMERICA. *Anthologia Anthropologica. A Copious Selection of Passages for the Study of Social Anthropology from the Manuscript Notebooks of Sir James George Frazer.*

Arranged and Edited by Robert A. Downie.

Percy Lund Humphries and Co., London.

35s. net. 11 x 8½; ix + 351; 1939.

These two volumes complete the publication of the material which Sir James Frazer has collected in his notebooks over a long period of research in social anthropology (for the two earlier volumes, cf. Q.R.B., Vol. 14, p. 353; Vol. 15, p. 85). The four volumes represent, in general, left-over material; that is, material that did not exactly fit in with the author's writings, yet was far too valuable to be discarded since frequently it was from sources that are not now easily available to the student. To Mr. Robert A. Downie fell the task of putting these miscellaneous notes into usable form. This he has done in a most competent and satisfactory manner.

All four volumes follow the same plan. A hasty glance through the table of contents will inform the reader whether a particular group is mentioned; or, in the index will be found a careful array of the subjects noted. The first of the present volumes, *Native Races of Asia and Europe* has the following main divisions: Indo-China, Tibet and China, Korea and Japan, Northern Asia, India, South-Western Asia, and Europe—each of these being subdivided. *Native Races of America* is divided into Greenland and North America, Mexico and Central America, and South America, with sub-divisions. The extracts, in English, German, French, or Spanish, are largely from nineteenth century writings, especially for the American volume, but there is also a goodly sprinkling of material from earlier periods. Among these we note Martini Cromeri,

Lithuania, 1568; Thevenot's *Relations des Divers Voyages curieux*, Paris, 1672; Thomas Hyde, *Historia religionis veterum Persarum eorumque Magorum*, 1700; Petri de Dusburg, *Chronicon Prussiae*, 1679; Antoine Biet, *l'Isle de Cayenne*, 1664; Pablo Joseph de Arriaga, *Extirpacion de la Idolatria del Piru*, 1621, etc. Catholic priests, officers of foreign expeditions, anthropologists, missionaries and travelers have all contributed in their writings to these interesting notes. An excellent outline map for each continent shows the localities of the races mentioned.



HISTORICAL TABLES.

By S. H. Steinberg. With a Foreword by G. P. Gooch. *The Macmillan Co., New York and London.* \$3.50. 9½ x 7½; x + 256; 1939.

A thorough and scholarly chronology covering a span of approximately 2000 years from 58 B.C., three years before Caesar first invaded Britain, down to the end of 1938, just 8 months short of the beginning of World War II and Hitler's attempt to repeat Caesar's performance. The arrangement is in six columns to the double page (except for the period of World War I). In general the three columns on each left-hand page deal chiefly with the relations of the Powers. The right-hand pages are, in the author's words, "given to what may be described as home affairs and the history of civilization; i.e. constitutional, economic, spiritual, and intellectual activities."

Relative to scientific matters the chronology gives a considerably larger proportion of details for applied than for pure science, which is perhaps natural considering the purpose of the whole work. But few events in the history of pure science of really major importance appear to have been omitted. The compactness of the book, coupled with the easy secular comparability afforded by the columnar arrangement make it one of the most useful books of its kind that has appeared. Every scholar, regardless of his field, will welcome it as a desk companion.

This volume, in common with most

tabular chronologies, is not indexed. This is a mistaken policy. The value and usefulness of the book would be increased many times over if it contained detailed author and subject indexes. This would be true even if the thickness of the volume were doubled, which it would not be. Suppose, for example, one has forgotten the year when Newton's *Optics* appeared, and wants to look it up. This, and other unindexed chronologies, leave one no resource except to run down the appropriate column, beginning say in the middle of the 17th century, until the desired entry is reached.

But even with this defect *Historical Tables* is a work of great value.



THE SWAZI: *An Ethnographic Account of the Natives of the Swaziland Protectorate.*

By Brian A. Marwick. The Macmillan Co., New York; The University Press, Cambridge. \$4.25. 8½ x 5½; xvii + 320 + 8 plates; 1940.

This, the first comprehensive work on the Swazi, includes descriptions of their social organization, social and economic life, religion and magic, political organization and legal system, and effects of European contact. The information incorporated in this valuable and very readable treatise was obtained from the author's nine years' experience in Swaziland as a government official, his visits to the native villages, and from the scanty literature on the subject.

That the Swazi culture remains a working whole in spite of the influence of European civilization is evident from the fact that "sanctions and institutions which existed prior to European influence still operate even where attempts have been made to uproot certain elements of culture," and frequent examples occur where Christian converts hurry to consult witch doctors as soon as trouble comes their way. In fact attempts by missionaries and officials to eradicate certain elements of native culture have often not brought the results desired.

Missionaries have insisted upon monogamy with the result that polygamy is becoming discountenanced. The woman who would have been con-

tent to become the wife of a polygamist now occasionally refuses to do so, but not infrequently becomes a prostitute or a concubine instead, since there are few occupations by which a native woman can earn her own living. The net result is that a woman who would have been accepted in society as a useful and respected social and economic unit is despised by the conservative natives and by the missionaries if she falls into loose ways as a result of the modification of the outlook upon polygamy.

Appendix I presents the results of studies by other authors which were published after the present book was written; Appendix II is a glossary of Swazi terms used in the text. Annotations and an index have been provided, and the illustrations consist of photographs and diagrams.



WESTWARD FROM VINLAND. *An Account of Norse Discoveries and Explorations in America 982-1362.*

By Hjalmar R. Holand. Duell, Sloan and Pearce, New York. \$3.00. 8½ x 5½; x + 354 + 31 plates; 1940.

When Holand published *The Kensington Stone* some years ago, it became inevitable that some day a larger volume would be undertaken, to which wider circulation should be given.

The objectives of the present work are threefold—to write briefly the history of the Norse settlements on Greenland as far as it has a bearing on the possible colonization of America; to prove the authenticity of the Kensington Stone; and to speculate as to the origin of the Mandans—that peculiar tribe of blond Indians who lived in frame houses and engaged in agriculture. The first two of these involved extensive traveling not only in Scandinavia, but throughout Europe, to examine artifacts in museums and documents in libraries.

Unfortunately, the urge that drove him to add the chapter about the Mandans appears all through the remainder of the book. The entirely unnecessary and irrelevant speculations in which the author enjoys indulging do not impair the validity of the conclusions he reaches, but neither do they add anything, and they are likely to exhaust the reader's patience. If the reader can manage to forget these speculations and concentrate his attention entirely

on the facts, he is likely to conclude, as the present reviewer has done, that Holand has proved his point; but it is a mystery that, after devoting over a quarter of a century to the search for facts in support of his theory, he is unwilling to let those facts speak for themselves.

The book is thoroughly documented with footnotes, but the lengthy bibliography in the earlier work has been omitted. The book is excellently illustrated with photographs, drawings, diagrams, and maps. There is an index of nineteen pages.



ÉTUDE SOCIALE COMPARÉE DES RÉGIMES DE LIBERTÉ ET DES RÉGIMES AUTORITAIRES. (*Essai d'Économie Sociale Comparée.*)

By Jean Lescure. *Les Éditions Domat-Montchrestien, Paris.* 80 francs. 9 x 5½; 479 + 1 folding chart; 1940 (paper).

The author discusses in detail the philosophy and theoretical principles underlying the political economy of Russia, Germany, and Italy, and examines the results of the attempts made to develop the economic life of these countries according to the political and social ideologies. As is known, in the totalitarian states mentioned the government exercises either directly or indirectly a preponderant control over both capital and labor. The degree and manner of this control differ in the three countries, being most comprehensive in Russia and the least in Italy. The major and more important portion of this book is dedicated to a delineation of these differences. The clearness with which the distinctive and differentiating elements of these doctrines are outlined is remarkable and makes this book a first class contribution to economic and social literature and one especially to be read by those who speak glibly about political ideologies. The author notes and emphasizes with much satisfaction that in practice the totalitarian systems cannot escape the fundamental laws of economics. Prices are still determined by supply and demand, capital is formed by savings, private initiative is necessary for the development of enterprises. No matter what the ideology the economic

laws still triumph, says the author with verbal transports of joy. Since this volume embodies lectures given to students, the author's naive tone may be forgiven but it must not be forgotten that long ago the mathematical economists adequately demonstrated the consequences relative to price, production, and consumption of alterations in the postulates that characterize a liberal economy. The results observed in the totalitarian states, in Japan, and in this country only furnish further proof of the validity of the deductions.



ONCE IN SINAI. *The Record of a Solitary Venture.*

By Joan M. C. Plowden. *With a Foreword by Major C. S. Jarvis. Methuen and Co., London.* 12s. 6d. net. 8 x 5½; xv + 302 + 8 plates + 1 folding map; 1940.

This is a delightful story of travel and exploration. The author denies that she had any adventures but those who read the account of the man-eating shark will disagree with her.

Although one of the world's bleakest deserts, the peninsula of Sinai is full of romance. Tradition makes it the land of Midian. In ancient history it was the scene of the Exodus and it was here that Elijah survived the wind, the fire, and the earthquake, and heard the still small voice. The mediaeval period saw the erection here of the convent of Saint Catherine of Alexandria (not to be confused with St. Catherine of Siena) and in modern years it acquired associations with Tischendorf and the Codex Sinaiticus.

Being so largely a record of personal experience the book contains little in the way of original contributions to science, but one incident may be mentioned. On a mural in the convent of Saint Catherine, which was built in the reign of Justinian, is the figure of a dodo. Now this bird was not known to science until the sixteenth century. Is it possible that there were dodos on the peninsula of Sinai at an early period that have since become extinct? The description of the quail in the Biblical account that stood

two cubits above the ground implies that there may have been. But the author is not a biologist and does not pursue the matter further.

The book is well illustrated with the author's photographs, and her route can easily be followed by means of numerous maps.



JAPAN'S EMERGENCE AS A MODERN STATE. *Political and Economic Problems of the Meiji Period.* I.P.R. Inquiry Series.

By E. Herbert Norman. Institute of Pacific Relations, New York. \$2.00. 9 x 6; xiii + 254; 1940.

The year 1868, the year of the so-called Meiji Restoration, marks the beginning of the transformation of Japan from a feudal agrarian state to a modern industrial nation that can compete with the United States and Great Britain. In that year one group of aristocrats wrested the power from the controlling group and aided by the financial support of the leading banking houses was able to alter the economy of the country according to its will. Thus, as the author well emphasizes, what took place was not a revolution by the people but merely a change of authority from one to another set of persons among the ruling castes. The latter, being composed of able and far-sighted men, recognized the significance of the economic evolution of the leading Western countries and decided to follow suit while at the same time they attempted and at times succeeded in avoiding some of the errors that accompanied the industrial and commercial development in Europe and this country. Furthermore, Japan was fortunate because being small and with limited natural resources it did not excite the cupidity of the Western powers and was saved from the fate of China. These seem to be the principal factors affecting the progress of Japan as described in this account which covers the commercial, agricultural, and industrial, as well as political changes in Japan from 1868 to the Russo-Japanese conflict. Within the limits of the subject discussed this scholarly monograph is interesting not only for its timeliness but also because of the style in which it is written.

WHITE WATER AND BLACK MAGIC.

By Richard C. Gill. Henry Holt and Co., New York. \$3.00. 8½ x 5½; xiv + 369; 1940.

This is the story of the Rio Pastaza whose turbulent, rock-torn white waters flow with eager haste through the land of the Ecuadorian Oriente to the Mother Amazon; it is the story of the Ecuador Indians and their "flying death," curare, in the preparation and use of which the black magic of the jungle pharmacologists play a paramount rôle; it is the story of the conversion of curare from the lethal poison of witchmen to the therapeutic drug of "men in white"—a drug beneficial in cases of spastic paralysis, as a shock-absorber in convulsive shock therapy in psychiatric treatment, and possibly in other therapeutic fields. The author, an ethnobotanist, and his wife live on the hacienda, Rio Negro, a plantation ranch molded out of "wild living forest," on the Pastaza in the Ecuadorian hinterland. It was to this ranch that all wanderers on the Pastaza Trail came—solitary Indian hunters and messengers, jungle chieftains with their tribal retinues, "miscellaneous" scientists, old-timers, new-timers, school teachers, petty adventurers, prospectors, missionaries, journalists, colonists-to-be, colonists-who-had-been, etc., and it was from this ranch that the author traveled into the jungle to live in Indian villages, to learn more about the pharmacopoeia of the forest, and to become an accredited medicine man among the Indians. From this "jungle drugstore" the Gill-Merrill Ecuadorian Expedition brought back enough botanical specimens of curare for large scale medical research, as well as other important herbs. The volume includes duplicate maps on the inside front and back covers, numerous photographs, and an index.



THE DISCOVERY OF MAN. *The Story of the Inquiry Into Human Origins.*

By Stanley Casson. Harper and Bros., New York and London. \$3.00. 8½ x 5½; 339 + 16 plates; 1939.

This is an outline of the more important developments and personalities in the history of cultural anthropology and

archaeology. Although with Aristotle, Herodotus, and Tacitus, the ancient world contributed greatly to our knowledge of these aspects of human biology, it is really only from the 17th and 18th centuries that systematic progress began, and the author justly dedicates the major portion of the book to the pioneers of that epoch. The author opens this history with an account of the "pilot books" of the Carthaginian Hanno. He mentions in passing Anaximander and Archelaus, to discuss more leisurely Herodotus, Hippocrates, Aristotle, Pliny the elder, and Tacitus. He is little impressed by the writings of the Romans and singles out Pliny, particularly, with ironic and sarcastic comments. Following the Renaissance and the discovery of America the first systematic observations on cultural anthropology are reported, notably that of John Scheffer (1674); and with the work of Stukeley (1687-1765) some beginning is made in archaeological field investigations. The progress thereafter becomes accelerated, leading to our present knowledge on the subject. In discussing the modern contributions the author is interested primarily in the theorists, especially the English theorists. The book suffers from this change of method and accompanying style. While the first part is interesting and easy to read, the latter sections have the scholarly but pedantic qualities of a synoptic history text.



ÉTAT DE LA POPULATION D'APRÈS LES RECENSEMENTS. MIGRATIONS. *Actualités Scientifiques et Industrielles*, 786. *Cours de Démographie et de Statistique Sanitaire*. III.

By Michel Huber. Hermann et Cie, Paris. 30 francs. 10 x 6½; 108; 1939 (paper).
NUPTIALITÉ, NATALITÉ, FECONDITÉ. *Actualités Scientifiques et Industrielles*, 801. *Cours de Démographie et de Statistique Sanitaire*, IV.

By Michel Huber. Hermann et Cie, Paris. 40 francs. 10 x 6½; 131; 1939 (paper). The first two numbers in this series were published in 1938 under the titles *Introduction à l'étude des statistiques démographiques et sanitaires* (No. 598) and *Méthodes*

d'élaboration des statistiques démographiques (recensements, état civil, migrations) (No. 599), respectively.

In Number III the author presents data on the total population of the earth and its distribution by geographical areas; methods of census taking used in various countries, and the enumeration of the various kinds of data on the distributions of populations by age, sex, civil status, language, religion, etc. that can be obtained from census material; and migration.

Number IV illustrates from actual data, the type of information that can be calculated from census material and from birth and death registrations concerning number and rates of marriages, divorces, births (live and still, legitimate and illegitimate), sex ratios at birth, infant mortality, and fertility. A large part of the illustrative material pertains to France in the last quarter of a century.



O. C. MARSH: *Pioneer in Paleontology*.

By Charles Schuchert and Clara M. LeVene. Yale University Press, New Haven; Oxford University Press, London. \$5.00. 9½ x 6½; xxi + 541 + 30 plates; 1940.

Whatever Othniel Marsh's peculiarities (to use a milder word than some of his contemporaries would have) of character and personality may have been, he was one of the great figures in the history of vertebrate paleontology. A definitive biography has long been needed. The need is admirably filled by the present volume. The authors had unusual, indeed almost unparalleled, facilities for the task, in the way of access to Marsh's papers, collections, and *memorabilia* of all sorts and kinds. They have made excellent use of these resources, and have turned out a book that is readable, as well as accurate and detailed, about a man who was intrinsically somewhat lacking in charm or interest of personality, as those words are usually understood. All the testimony, including that of this book, indicates that Marsh was a pompous, selfish, vain, strutting sort of a Tory, who never in his life had the smallest conception that the pleasures of con-

descension were singularly one-sided, as Stevenson put it. His attitudes and relations towards and with assistants and colleagues present a picture that can scarcely be regarded as either pleasant or normal. None the less he was indubitably a great paleontologist, and this volume is a contribution of first rate importance to the history of science. The book is adequately indexed and illustrated.



RUTHERFORD: *Being the Life and Letters of the Rt. Hon. Lord Rutherford, O.M.*

By A. S. Eve. Foreword by Earl Baldwin of Bewdley. The Macmillan Co., New York; University Press, Cambridge. \$5.00.

9 $\frac{1}{2}$ x 6 $\frac{1}{2}$; xvi + 451 + 18 plates; 1939.

In this first authorized biography of one of the greatest of modern scientists the author has not only recorded in sequence the salient facts of his subject's life and scientific contributions, but in addition, has devoted a major portion of the book to the correspondence that passed between Rutherford and his wife, his mother, and his colleagues. As a consequence, the reader is enabled to catch a glimpse of a live and very human Rutherford. It is no more than a glimpse because the author seems to take special care in avoiding comments on the personality of his hero and from the correspondence only a disconnected and fragmentary view is obtained. It would appear that Rutherford was a cocky fellow, well aware of his genius and not too modest about it. Early in life he became interested in the detection of Hertzian waves and began inventing apparatuses for the purpose. From his native New Zealand he went to Cambridge where, under J. J. Thomson, his career took its shape. Through the latter he obtained the post at McGill and there were initiated the investigations that led to the Nobel prize, fame, glory, and an English peerage. Rutherford lived a full and interesting life and the author has succeeded in describing it so well that this will undoubtedly rank among the best of biographical sketches to appear in recent years.

CULTURAL AND NATURAL AREAS OF NATIVE NORTH AMERICA. *University of California Publications in American Archaeology and Ethnology. Volume 38.*

By A. L. Kroeber. University of California Press, Berkeley. \$3.50 (cloth); \$3.00 (paper). 10 $\frac{3}{4}$ x 6 $\frac{1}{2}$; xi + 242 + 9 folding maps + 1 folding table; 1939.

This is a comprehensive, extensively documented work on the cultural and natural areas of native North America from the Arctic Circle to the region of Central America. The tribal, cultural, physiographic, and vegetational areas of North America are discussed and pictorially presented in many textual and loose maps, the latter of which are enclosed in a pocket at the end of the text. Population densities are given by tribes, areas, language groups, etc. Environmental and cultural factors are presented in relation to physiography, natural vegetation, climate, water, and drainage. Invaluable to the student is the author's evaluation of literature and discussion of theories expounded in the broad field of cultural anthropology on the native cultures of North America. Bibliography and notes are not separately appended but appear in the textual matter and footnotes. An index and a detailed table of contents are included. The 17 text tables, 21 text maps, 1 pocket table, and 8 pocket maps should be of inestimable aid to the student in this field.



HUMAN BIOLOGY.

By George A. Baitsell. McGraw-Hill Book Co., New York and London. \$3.75. 9 x 6; xv + 621; 1940.

Baitsell's text is a needed contribution to a new field of modern science in which acceptable textbooks are few and far-between. This distinctly new and refreshing book endeavors to present the pertinent facts of biology from the vantage ground of the most interesting and important organism in the world of life—man himself. Accordingly, the study of human biology involves a great deal more than human anatomy and physiology: it is essentially a humanizing of general

biology in that attention is centered primarily on human structure and function rather than on the characteristics of types selected from the lower organisms. In an endeavor to widen the scope of the book, so that the interested student may have abundant material to pursue important fields of interest at advanced levels, an appendix has been supplied containing direct quotations from the publications of various authorities. Original material by the author is also presented. The book is well and appropriately illustrated and a complete index has been included.



PENOBSCOT MAN. *The Life History of a Forest Tribe in Maine.*

By Frank G. Speck. University of Pennsylvania Press, Philadelphia; Oxford University Press, London. \$4.00. $9\frac{1}{2} \times 6\frac{1}{2}$; xx + 325; 1940.

Much has been written about the Indians of western North America while comparatively little ethnological work has been done among the tribes of northern New England and eastern Canada. The present work is a fine contribution to this neglected field.

Personal contact with the Penobscot Indians of Maine, beginning in 1909 when they were still an independent forest people instead of curiosities for the tourist, makes Frank G. Speck an authority on this tribe of the Algonkians. He tells of their history, their folk-lore, their daily round of life, their physical and mental characteristics, and their adjustment to the white man's world. As one closes this book one wishes with the author that these interesting inhabitants of the old forests need not have become steel-workers and factory hands.



FIJIAN FRONTIER. *Studies of the Pacific No. 4.*

By Laura Thompson. Introduction by B. Malinowski. American Council, Institute of Pacific Relations, San Francisco, New York and Honolulu. \$2.00. 9×6 ; xxiii + 153 + 7 plates; 1940.

This study, which Malinowski in his introduction terms "an artistic picture of primitive life in one of the most fascinating parts of the world," gives an analysis of the history of the Fijians, their customs, their religion, their psychology, and their reactions to the presence of civilizing influences. Thompson believes that when the natives of the Fiji groups have been educated to make the fullest use of their native resources, both manual and natural, and when the present pauperizing influences of soliciting and ceremonial giving are banished, the term "famine isles," with all that it implies will be lifted for once and for all from these picturesque British-owned islands in the tropical Pacific.



DOCTORS IN SHIRT SLEEVES: Musings on Hobbies, Meals, Patients, Sport and Philosophy.

Edited by Sir Henry Bashford. Veritas Press, New York. \$2.00. $8\frac{1}{2} \times 5\frac{1}{2}$; xii + 294; 1940.

The twenty-five entertaining essays appearing in this volume were selected from a series of articles on diverse subjects contributed by medical men to the *Lancet* and published therein as a weekly feature under the heading "Grains and Scruples." Hobbies, reflections, reminiscences, personal experiences, and theories—gastro-nomic, literary, biological, educational, spiritual, etc.—form the subject matter of the essays. Each contributor has been given full freedom in choice of subject and style of writing. The fortunate result, the present volume, is a compilation of the "off-duty musings" of medical men who write in a witty and knowing way on a diversity of subjects.



THE MAN IN THE MOONLIGHT.

By Helen McCloy. William Morrow and Co., New York. \$2.00. $7\frac{1}{2} \times 5\frac{1}{2}$; [6] + 312; 1940.

In these *Brief Notes* comments on novels are rarely included. But the present volume has a distinctive right to be present. It is a biological detective story that is good; both as story and as human

biology. The master mind, Basil Willing, is a competent and sensible psychiatrist; the action takes place in and about a university in New York City not terribly difficult to identify under its pseudonym; and the professors involved in the story behave more nearly as actual professors do than is the case in most fiction. Furthermore the scientific matters, with which the book teems, are handled throughout with considerable real understanding. Mostly the professional scientific man will not gag as he reads the book, which is saying a lot as the bulk of pseudo-scientific fiction goes. Regrettably we do not have the pleasure of knowing Helen McCloy personally, or anything about her. But on the evidence afforded by this volume she is certainly to be encouraged to go on writing.



CANOE TO MANDALAY.

By Major R. Raven-Hart. *Frederick Muller, London.* 10s. 6d. net. $8\frac{1}{2} \times 5\frac{1}{2}$; [4] + 245 + 16 plates; 1939.

Major Raven-Hart's 16,000 miles canoeing experience served him well on his Burmese journey of 600 miles which took him from Myitkyina down the Irrawaddy to Rangoon. With only the help of a 15-year-old lad, and at the risk of contracting malaria or the plague, or of capsizing in the whirlpools of the river, the author made the perilous journey without any major mishap. The places he visited, the people he met, as well as his experiences in learning the Burmese language and customs, are set down in a most fascinating and readable fashion. The author's spicy humor is only one of the many factors which make for thoroughly enjoyable reading. The text is generously supplied with photographs of the people and places visited. The concluding pages of the book contain an appendix of practical details, a table of distances, and an index.



A MAN WHO FOUND A COUNTRY.

By A. Nakashian. *Thomas Y. Crowell Co., New York.* \$2.75. $8\frac{1}{2} \times 5\frac{1}{2}$; viii + 279; 1940.

The author's experiences in a country so entirely different from our own makes most fascinating reading. An Armenian, living under Turkish rule, Dr. Nakashian was a subject from the outset of prejudice and persecution. Through determination and a blind trust in luck he managed to obtain a medical degree at the American University then newly established at Beyrouth. His subsequent practice led him among beggars, thieves, rich lords, and high officials, while at the same time he and his family were in almost constant flight for their lives. During the World War the author was imprisoned for months but was released and made a captain in the Turkish army because of the dire need for surgeons. When racial and religious persecutions continued after the war, the family moved to this country. The book not only pays tribute to the American doctors and missionaries who worked in the Near East, but it is also an interesting and well-written historical account of the fall of the Ottoman Empire.



SCOTT OF THE ANTARCTIC. *A Study in Character.*

By George Seaver. *John Murray, London.* 10s. 6d. net. $8\frac{1}{2} \times 5\frac{1}{2}$; vii + 187 + 14 plates; 1940.

When Captain Scott set out on his expedition to the South Pole, he had two purposes in mind: (1) British priority at the Pole; and (2) the satisfying of his own quest for exploration and adventure. Although he failed in the former by a mere month, the latter purpose was completely fulfilled, as attested by his diary in which he wrote his experiences right up to the minute of his death. Faced with unsurmountable difficulties, and always working against great odds, Scott was a man who never gave up. His heritage and early training, his physical, moral, and intellectual characteristics, his failures and successes, all of which contributed to his indomitable spirit, are interestingly recorded in this little volume by Mr. Seaver. The story of Scott's life will be read and enjoyed, not only by Britishers, but by all throughout the English speaking world who are interested

in exploration, adventure, and human character.



GOVERNMENTS AND BIRTH CONTROL. *Population Increase Versus The Kingdom of God on Earth.*

By F. E. Austin. *The Austin Workshops*, Hanover, N. H. \$1.00. 6 x 4½; 130; 1940.

According to the author's statement thirty-two pages of this book are alone worth at least sixteen dollars. But in the prologue he still expresses some fear lest reviewers should find that it has no meritorious features. Let it be said that Mr. Austin points out some of the fundamental biological truths regarding war and overpopulation. Numerous figures, some of them valid, others rather comical, are presented to show that the world is fast going to the dogs. Two alternatives remain—wholesale annihilation of populations, or radical limitation of births. Among the pages is considerable discussion about the establishment of a Heavenly Kingdom on earth by the United States and Great Britain, with the "isms" doomed to failure because they are not in accord with Divine command, all this being supported by numerous biblical quotations. Let us all take precautions against Armageddon!



THE ATLANTIC MIGRATION 1607-1860. *A History of the Continuing Settlement of the United States.*

By Marcus L. Hansen. Edited with a Foreword by Arthur M. Schlesinger. Harvard University Press, Cambridge. \$3.50. 8½ x 6; xvii + 391 + 9 plates; 1940.

The continuing migration of the peoples of the Old World to the Western Hemisphere, and particularly to North America, has been one of the most important and significant migratory movements from every point of view, of which there is record in history or evidence in prehistory. The late Professor Hansen has provided in this volume a thorough, scholarly, comprehensive, and readable account of this movement and its consequences and

implications. The book is thoroughly documented and indexed, the *Bibliography and Notes* occupying over 60 pages. The approach and treatment in this volume is analytic throughout. Synthesis would doubtless have followed if Prof. Hansen had lived longer. But as a clear, logical, and sound untangling of an intricate web of social forces of extreme complexity this book will have permanent value to historians, sociologists, and human biologists generally.



ARGENTINE TO ANDES.

By Hanna Rydh. Translated from the Swedish by Mary Sandbach. Blackie and Son, London and Glasgow. 10s. 6d. net. 8½ x 5½; xi + 171 + 47 plates; 1940.

This is an exciting and refreshing account of a rather unique journey told in a most readable and friendly manner. Dr. Rydh, a Swedish archaeologist, went to South America on a lecture tour, and while there, took the opportunity of visiting the chief centers of those civilizations which existed before the arrival of the Spanish and Portuguese. Traveling from Buenos Aires to La Paz, the author stopped to study the remains in the northern provinces of Argentina on the eastern slopes of the Andes, and near the borders of Bolivia. She was greatly interested in the Inca ruins around Lake Titicaca and in Cuzco, the very center of the Inca empire. During her stay in Cuzco, the feast of Corpus Christi was celebrated and her description of the ceremony is most graphic. The book concludes with a charming description of the city of Lima. The volume is exceptionally well illustrated and an index has been provided.



RACE, LANGUAGE AND CULTURE.

By Franz Boas. The Macmillan Co., New York. \$5.00. 9½ x 6½; xx + 647; 1940.

This volume, a compilation of sixty-three papers by Franz Boas, represents the basic anthropological views of one of the most dominant figures in the field of anthropology. The articles were chosen by

Boas from his numerous publications of the past fifty-odd years, the earliest printed in this volume being *The Study of Geography* (published 1887) and the most recent, *Growth* (1892-1939, revised and condensed).

Hitherto many of the works of Franz Boas were more or less inaccessible to students, due to the fact that his writings have appeared in numerous journals. Boas's researches extend into all branches of anthropology and this work is a collection of his more important contributions to the fields of physical and cultural anthropology. There are numerous graphs, drawings, and photographs. A detailed table of contents takes the place of an index.



AN INTRODUCTION TO CULTURAL ANTHROPOLOGY. *A New and Enlarged Edition.*

By Robert H. Lowie. Farrar and Rinehart, New York. \$3.50. 8½ x 5½; xx + 584 + 16 plates; 1940.

Part I of this edition has remained essentially unchanged from the 1934 publication reviewed in this journal (cf. Vol. 10, p. 347). Entirely new chapters discuss language and the theory of culture. The author upholds the view that cultural variations between peoples are separate and distinct from racial differences. The second part of the volume, almost entirely new and supplementary to the first edition, treats typical cultures, including our Western civilization as well as several primitive tribes. A number of maps and drawings accompany the text and the volume is made complete by an index and enlarged bibliography of 16 pages.



ADVENTURES OF A BIOLOGIST.

By J. B. S. Haldane. Harper and Bros., New York and London. \$2.75. 8½ x 5½; vii + 281; 1940.

This volume consists of a series of essays—already published through some medium or other—which are, as Haldane says, "by-products of my other activities, namely scientific teaching and research, and, since 1936, political work." In

essence they describe intellectual explorations into human biology and are written in a smooth smart style that will probably appeal more to the so-called intelligentsia than to the general public. A multitude of topics is covered, all to some degree cosmic: climate, origin of life, the geophysical universe, etc. About one half of the essays deal with problems of sociology: of course included is also a note on Marxism. The reader, even though not particularly interested in Professor Haldane's feelings and thoughts about such matters, will undoubtedly enjoy the book.



EMIGRANT COMMUNITIES IN SOUTH CHINA. *A Study of Overseas Migration and Its Influence on Standards of Living and Social Change.*

By Ta Chen. English Version Edited by Bruno Lasker. Institute of Pacific Relations, New York. \$2.50. 9 x 6; xvi + 287; 1940.

The field study on the emigrant communities of East Kwangtung and South Fukien in South China was undertaken as an inquiry into the "nature and consequences of cultural change in the Pacific" and "into the part played by Chinese emigration to the near-by countries of the South in changing the standards of living in the home communities. . . ." This research on the causes and cultural effects of emigration should be of great interest to the student of migration, culture diffusion, and sociology. There are numerous tables, three appendices, and an index.



INGALIK MATERIAL CULTURE. *Yale University Publications in Anthropology. Number 22.*

By Cornelius Osgood. Yale University Press, New Haven; Oxford University Press, London. \$4.00. 9½ x 7; 500 + 11 plates; 1940 (paper).

The data on which this volume has been based were recorded in the Alaskan village of Anvik during the summers of 1934 and 1937, under the auspices and

with the financial support of Yale University. The present work is the first of an intended series of papers. It deals primarily with descriptive data from the analytical point of view. Later it is hoped to present a consideration of certain ethnological theories to which these data from the north are pertinent. The book is illustrated with numerous line drawings, maps, and photographs. The appendices furnish additional Ingalik information of diverse character. There is a bibliography and an index.



ADVENTURES IN GOOD EATING. *Good Eating Places Along the Highways of America. Seventh Edition.*

By Duncan Hines. *Adventures in Good Eating, Bowling Green, Ky.* \$1.50. 7½ x 5; 296; 1940 (paper).

The automobile traveler unconsciously has had no small part in the production of this guide that now appears in its seventh edition (tenth printing—the first edition appeared in 1936). It seems to be thoroughly dependable. Naturally it is not possible for one person to check up on all the places listed but apparently there are many competent and willing helpers. Occasionally there are omissions and doubtful inclusions. Some of these errors, however, will undoubtedly be ironed out with the continuation of the present standard of checking. Besides the United States the survey includes Canada, Alaska, Mexico, and Hawaii.



LABORATORY OF ANTHROPOLOGY. *Technical Series, Bulletin No. 10. Archaeological Survey.* Containing the following articles: *A Variation of Southwestern Pueblo Culture*, by J. D. Jennings; *Analysis of the Skeletal Material*, by Georg Neumann.

Laboratory of Anthropology, Santa Fe, N. M. \$1.25. 10½ x 8½; 20 + 8 plates; 1940 (paper).

The slow and arduous task of excavation in the attempt to learn more about the life and activities of pre-historic man of North America has taken many scientific groups into the rich fields of Indian

culture of the southwestern United States. The present bulletin describes the industrial and skeletal finds of three excavations in the Peñasco River Valley of New Mexico. Everything found was indicative of a southwestern Pueblo culture dating somewhere around 1150–1300.

A short bibliography, and several maps and photographs conclude the paper.



CONTRIBUTIONS TO THE RACIAL ANTHROPOLOGY OF THE NEAR EAST. *Papers of the Peabody Museum of American Archaeology and Ethnology, Harvard University. Vol. XVI, No. 2.*

By Carl C. Selzer. *Based on Data Collected by Henry M. Huxley. With a Foreword by Henry M. Huxley. Peabody Museum of Archaeology and Ethnology, Cambridge.* \$1.00. 9½ x 6½; x + 62 + 8 plates; 1940 (paper).



ZOOLOGY

THE LOUSE: *An Account of the Lice Which Infest Man, Their Medical Importance and Control.*

By Patrick A. Buxton. *Williams & Wilkins Co., Baltimore.* \$3.00. 8½ x 5½; ix + 115; 1940.

It is apparent that our generation is the first in the history of mankind to think the human louse sufficiently important to warrant any particular activity from man other than that of scratching. In this important treatise Buxton has recorded much of the recently gathered knowledge of the human louse, with special reference to its life and activities, its importance as a vector for infectious diseases, its control, as well as the methods used in rearing it in the laboratory for experimental purposes. From the medical point of view, the treatment of the subject is complete. Much space is devoted to the relations of the louse to the *Rickettsias* and *Spirochaetes* responsible for typhus and relapsing fever respectively. The belief that each of these diseases is spread by rubbing either the feces or the fluids from the broken bodies of the lice into

abrasians of the skin, rather than by the bite and blood sucking process of the louse, is thoroughly documented, and appears to be universally accepted. From a biological point of view, there are many gaps in our knowledge concerning the human louse. The author states,

"There is no evidence that it [the louse] can establish itself and breed on other hosts. The only possible exception is of certain monkeys, from which lice hardly distinguishable from *P. humanus* have been recovered in zoological gardens; the simple experiment of infecting clean monkeys with human lice and observing the result has not yet been performed." "Several records appear to suggest that the blood of some animals (especially of rodents) is poisonous to *Pediculus*; no one has performed the simple experiment of comparing the length of life after sucking guinea-pig or rat with that of controls on man, or even of unfed controls." "With regard to digestion [in the louse] nothing is known."

In the admission of these gaps in our knowledge, Buxton suggests possibilities for research, though we wonder why these simple experiments were not performed by the author himself long ago—particularly the ones concerning the rearing of human lice on other hosts. If the human louse could be found to live, or could be induced to live and reproduce normally on a monkey, the present annoying method of rearing them on human subjects for laboratory work would be eliminated.

The text is well illustrated, completely indexed, and boasts a bibliography of 108 titles.



THE RATTLESNAKES, GENERA *SISTRURUS* AND *CROTALUS*. A Study in Zoogeography and Evolution. Special Publication Number Four.

By Howard K. Gloyd. *The Chicago Academy of Sciences, Chicago.* \$2.50. 9½ x 7; vii + 266 + [4] + 31 plates; 1940 (paper).

The origin, evolution, and dispersion of the rattlesnake make up the content of this authoritative and scholarly dissertation. The fact that snakes make poor fossils has been responsible for the meager paleontological material concerning the origin of the rattlesnake. However, it is almost a certainty that the rattler had

his origin in southwestern North America, and more particularly, the north central portion of the Mexican plateau. In general, the further the rattlesnake has migrated from this region, the greater have been the variations and specializations in its evolutionary process. According to the best evidence Gloyd has been able to gather, there was a widespread distribution of the genus *Crotalus* in the United States during Pleiocene times.

Some 45 species of rattlesnakes are described in detail, particular note being made of the variations in size and color, the distribution, range, and the affinities for other species. A key to the species and sub-species of rattlesnakes, a bibliography of 303 titles, a complete index, as well as numerous tables, graphs, and photographic plates of many of the species listed, indicate the completeness of the work.



FORAMINIFERA: Their Classification and Economic Use. Third Edition, Revised and Enlarged, with an Illustrated Key to the Genera.

By Joseph A. Cushman. *Harvard University Press, Cambridge; Oxford University Press, London.* \$6.00. 9 x 6; ix + 426 + 48 plates; 1940.

Biologists and palaeontologists are becoming increasingly aware of the importance of this great group of single-celled animals, of which nearly 500 genera are now recognized. In the oceans they occur in untold numbers, their tests (secreted material which hardens into shapes characteristic for each form) largely making up the thick ooze of the ocean floor. As fossils, in the Paleozoic and even younger formations, they formed thick limestone—the pyramids of Egypt are largely of such limestone. Since the species have definite geologic and geographic ranges, they are important in determining the age of sediments and the conditions under which they were deposited. Commercially, their importance is indicated by the fact that many petroleum companies now have in their laboratories workers who have a special knowl-

edge of fossil Foraminifera. In spite of the fact that several thousand papers have been written about the Foraminifera, practically nothing is yet known about the habits and physiologic character of the animal:—a new field for biological investigation is unfolding.

In the present edition of this fine authoritative work the plates and key to the families and genera, which were published as a second volume in the second edition, have been added to the text under a single cover. The bibliography (58 pages) is extremely useful. An important reference book for all biological laboratories.



A STATISTICAL STUDY OF THE RATTLE-SNAKES. VII. *The Rattle, Part 1. Occasional Papers of the San Diego Society of Natural History. Number 6, May 18, 1940.*

By Lawrence M. Klauber. *San Diego Society of Natural History, San Diego, Calif.* 8 $\frac{3}{8}$ x 5 $\frac{3}{8}$; 62; 1940 (paper).

This contribution maintains the high standard set by the author in his previous work on various aspects of the physiology and somatology of the rattlesnake. There are first discussed the many erroneous ideas concerning the use of the rattle: namely, as a mating call, as a call for help from other rattlers, to warn other rattlers from danger, to paralyze, decoy, charm, lure, and warn prey or other intruders, to prevent an attack on the tail, as a substitute for hissing, as a religious warning, and as a venom carrier. The author dismisses, with excellent reasons based on field observations, all the above suggested uses for the rattle except that of a warning to intruders. This he believes to be its sole function, and that it is put to this use only after procrypsis has been unsuccessful in preventing discovery. The discussion contains detailed analyses of the number and measurements of rattles from various species, together with the method of vibration, the process of growth and shedding, as well as a chemical analysis of the horny material which constitutes the rattle.

Features which add to the usefulness of

the paper are the table of contents and the list of 145 bibliographic references.



A FIELD GUIDE TO THE BIRDS: *Giving Field Marks of all Species Found East of the Rockies. Revised and Enlarged.*

By Roger T. Peterson. *Houghton Mifflin Co., Boston.* \$2.75. 7 $\frac{1}{2}$ x 4 $\frac{1}{2}$; xx + 180 + 40 plates; 1939.

The need for a field guide based on the field markings of birds was the prompting circumstance for the writing of this book. The author expects it to be used to supplement the standard ornithological works in identifying live birds on the wing, or on trees, or thickets at a distance, by impressions, patterns, and distinctive markings, rather than by the minute anatomical measurements and markings used by collectors.

In this edition, completely revised and enlarged, some 78 families of birds are described, including many genera and species native to that section of the North American continent east of the Rocky Mountains. The text is generously supplied with illustrations in color, and black and white. A list of home reference suggestions and an extensive index complete the volume.



ZOOLOGICA. *Scientific Contributions of the New York Zoological Society. Vol. XXV, Part 1, Numbers 1-10.*

New York Zoological Society, Zoological Park, New York. \$1.75. 10 $\frac{1}{2}$ x 7; 116 + 15 plates; 1939 (paper).

The following papers appear in this number: The breeding behavior of the common shiner, *Notropis cornutus* (Mitchill), by E. C. Raney; Divergence and probability in taxonomy, by Isaac Ginsburg; Miscellaneous notes on the eggs and young of reptiles, by Roger Conant and Alexander Downs, Jr.; Occlusion of the venom duct of Crotalidae by electrocoagulation: an innovation in operative technique, by D. B. Jaros; Eastern Pacific expeditions of the New York Zoological Society. XVII. A review of the American fishes of the family Cirrhitidae, by

John Tee-Van; Eastern Pacific expeditions of the New York Zoological Society. XVIII. On the post-embryonic development of Brachyuran crabs of the genus *Ocypode*, by Jocelyn Crane; New species of British Guiana Heterocera, by W. Schaus; A papillary cystic disease affecting the barbels of *Ameiurus nebulosus* (Le Sueur), caused by the Myxosporidian *Henneguya ameiurensis* sp. nov., by R. F. Nigrelli and G. M. Smith; Caudal skeleton of Bermuda shallow water fishes. IV. Order Cyprinodontes: Cyprinodontidae, Poeciliidae, by Gloria Hollister; The histology of the eye of the cave Characin, *Anoptichthys*, by E. B. Gresser and C. M. Breder, Jr.



NATURAL HISTORY OF THE BIRDS OF EASTERN AND CENTRAL NORTH AMERICA.

By Edward H. Forbush and John B. May.

Illustrated by Louis Agassiz Fuertes, Allan Brooks and Roger T. Peterson. Houghton Mifflin Co., Boston. \$4.95.

11½ x 7½; xxv + 554 + 97 plates; 1940.

This volume is a revision and abridgement of Forbush's very fine work *Birds of Massachusetts and other New England States*. The junior author's task, by no means an easy one in following Forbush, has been extremely well done. The work, originally in three volumes, has been abridged into one, and at the same time the field extended to include all the birds east of the Dakotas, Nebraska, and Kansas, as far south as Florida, and north through eastern Canada. Something over 100 species have been added. The life history and detailed descriptions of all species and sub-species which are commonly found in this area, whether breeding birds, winter visitors, or migrants, are given; and in order to make the list quite complete the "stragglers" or "accidentals" of the region are given in an appendix—but without descriptions.

Indexes are included for both scientific and common names and at the end of the volume are the fine colored illustrations by Fuertes, Allan Brooks, and Roger Peterson—97 plates altogether. The price of the book seems to us most moderate.

WONDER CREATURES OF THE SEA.

By A. Hyatt Verrill. D. Appleton-Century Company, New York and London. \$3.00. 8½ x 5½; xvi + 272 + 10 plates; 1940.

Rapidly swelling book lists are science books written for popular consumption with much of the superabundant esoteric terminology of the scientific world deleted. *Wonder Creatures of the Sea*, a successful addition to the above-mentioned lists, describes the habits and dwelling places of invertebrates found on sea shores, in streams, tidepools, bays, and in the ocean's depths. There are splendid color and action descriptions of such denizens of the seas as sand-dollars, sea-urchins, king-crabs, starfishes, lobsters, sea-cucumbers, sponges, spider-crabs, corals, sea-squirts, and innumerable others. The scientific status (families, genera, etc.) of the wonder creatures is omitted whenever possible as is also a minutely detailed description of their anatomy. There are many excellent line drawings by the author. Photographs and index are included.



THE COD FISHERIES. *The History of an International Economy.*

By Harold A. Innis. Yale University Press, New Haven; The Ryerson Press, Toronto; Oxford University Press, London.

\$3.50. 9½ x 6½; xviii + 520; 1940.

Cod fishing was very important to the economics of the early inhabitants of the American sea coast. This harvest obtained from the sea for a long time rivalled the produce of the opening wilderness. Even today, although its importance has been relatively lessened by the rise of industry, it remains a world of its own in international economy, one in which the interplay of American, Canadian, and European interests has created a situation unique in history. The narrative begins with a chapter on European history. This is followed by a description of more recent times, when cod fisheries passed almost completely into the hands of the seamen of New England and Nova Scotia. The work contains many footnotes and is well indexed.

STUDIES IN THE MECOPTERA. Containing: *Biology and Morphology of Some North American Bittacidae (Order Mecoptera)*, by L. R. Setty; *The Genital Anatomy and Mating Behavior of Boreus brumalis Fisch (Mecoptera)*, by Kenneth W. Cooper.

The American Midland Naturalist, University of Notre Dame, Notre Dame, Indiana. \$1.00. 9 x 5½; III; 1940 (paper).

The detailed report (including 178 line drawings, 68 references) on the biology and morphology of some of the hanging-flies of North America adds appreciably to the hitherto meager knowledge of these insects that are beneficial to man. Adult bittacids (the adaptation of their hind legs for food-getting is unique) feed on flying mosquitoes: the larvae are scavengers. In addition, the bittacids, in all stages, are excellent material for biology teaching.

Much new material is included in the second of these papers (9 figures, 30 references). In spite of marked internal differences, the mating behavior of *Boreus brumalis* is identical with that of *B. hymalis*. Correspondingly, the external genitalia are remarkably similar.



BRAIN AND BODY OF FISH. *A Study of Brain Pattern in Relation to Hunting and Feeding in Fish.*

By H. Muir Evans. *The Blakiston Co., Philadelphia.* \$3.50. 9½ x 6; 164; 1940.

The author has chosen *Brain and Body of Fish* for his title

because this condenses in a phrase the remarkable fact that the external conformation of the brain of a bony fish indicates its habits and mode of feeding. In other words, the study of the external condition of the brain in bony fish is an index of the development of those organs belonging to the various sensory faculties.

The brain patterns, bodily structure, and habits of such teleosts as the Cyprinidae (carps), Clupeidae (herrings), flat-fishes (halibuts, soles, flounders, plaices, turbot), Gadidae (cods), and the Anguillidae (eels) are described and the relation between form and function discussed. Numerous drawings by the author illustrate the text material. There is a brief

table of contents, but unfortunately no index to either the text or the drawings.



THE BRANCHIOBELLELLIDAE (OLIGOCHAETA) OF NORTH AMERICAN CRAYFISHES. *Contribution from the Zoological Laboratory of the University of Illinois No. 537.*

By Clarence J. Goodnight. *University of Illinois Press, Urbana.* \$1.00. 10½ x 7; 75; 1940 (paper).

This is a monograph of annelid worms symbiotic with crayfish, of which nine genera and twenty-one species are known to inhabit the rivers of North America. Of these, three species and one genus are new and another genus has not hitherto been reported from this continent. There are also a few new terms of subgeneric and subspecific rank introduced. The geographic ranges of these animals are quite extensive, and seem to be independent of the size of the stream in which they occur. Also there is no host specificity, so that any worm may cohabit with any crayfish. There are sixty-four items in the bibliography, the oldest of which dates from 1805.



CHECK-LIST OF BIRDS OF THE WORLD. Volume IV.

By James Lee Peters. *Harvard University Press, Cambridge; Oxford University Press, London.* \$4.00. 9 x 6; xii + 291; 1940.

Volume 4 of this invaluable check list (for Volume 1, cf. Q.R.B., Vol. 7, No. 3; for Volume 3, cf. Q.R.B., Vol. 12, No. 4) deals with the cuckoos (including the African family of plantain-eaters), owls, goatsuckers, and swifts. The treatment of the forms has been brought up to 31 December, 1938, although a few forms described in 1939 are included. Mostly, these orders have not been completely described since the turn of the last century.

It is interesting at this stage in the development of the *Check-List* to compare the number of genera and species of Sharp's Volume I, issued in 1899, with the forms recognized in the first four volumes of Peters (1931-1940) covering the same orders: Sharp lists 830 genera, 3626 species; Peters lists 569 genera, 5106 forms.

ANTILLEAN TERRAPINS. *Memoirs of the Museum of Comparative Zoölogy at Harvard College, Vol. LIV, No. 5.*

By T. Barbour and A. F. Carr, Jr. *Museum of Comparative Zoölogy, Cambridge, Mass.* \$6.00. 12 x 10; 35 + 9 plates; 1940 (paper).

The West Indian terrapins of the genus *Pseudemys* comprise a section of the wide-ranging *scripta* group, being most closely allied to the Central American *P. scripta ornata*. The *scripta* group is distributed, through a series of integrading forms, from North Carolina into South America. Nine forms are listed and described in this monograph—in the *terrapen* sub-groups, five forms of which two are new sub-species; in the *stejnegeri* sub-group, four forms of which one is a new species and one a new subspecies. A bibliography of 58 titles accompanies the text—also a group of very fine colored plates (31 figures).



AMOUR DE LA CHASSE.

By Jean-É. Benech. *Éditions Stock, Paris.*

18 francs. 7½ x 4½; 173; 1939 (paper). This little book traces the life of the hunter and his joys and sorrows from the time he listens of an evening, as a little tot, to the stories of his elders; learning the habits of animals and to recognize their tracks; the time when he is first allowed to handle a gun; his first hunt and his later experiences up to the time when he is an old man and has to content himself by reciting his "adventures" to a younger generation. Delightfully written, the book also contains much material on the habits and food of animals and birds, and the aspects of the country-side during the four seasons.



ANIMAL BIOLOGY. Second Edition.

By Robert H. Wolcott. *McGraw-Hill Book Co., New York and London.* \$3.50.

9 x 6; xxi + 649; 1940.

This edition differs little in aim and presentation from that of the first edition (Q.R.B., Vol. 9, No. 1). It is an elementary textbook in zoology. The vol-

ume is not intended as a reference and for this reason technicalities are minimized. All morphology is eliminated as the author holds this portion of zoology is best handled by laboratory work. The book possesses many new illustrations, a glossary, and an index.



HERPETOLOGICAL RESULTS OF THE VERNAY ANGOLA EXPEDITION. *With Notes on African Reptiles in Other Collections. Part I. Snakes, Including an Arrangement of African Colubridae. Bulletin of The American Museum of Natural History. Volume LXXVII.*

By C. M. Bogert. *American Museum of Natural History, New York.* 90 cents. 9 x 6; 107 + 1 plate; 1940 (paper).

Added to the main collections of the Vernay Angola expedition of 1925 are specimens from 16 other collections from various African sources. The specimens, totalling 549, are distributed among 6 families, 52 genera, and 116 species and subspecies. Six are described as new or hitherto unrecognized forms. Many line drawings and photographic plates form part of the report.



A RACE OF THE WARBLING VIREO FROM GUERRERO, MEXICO. *Transactions of the San Diego Society of Natural History, Volume 9, No. 16.*

By A. J. van Rossem. *Society of Natural History, San Diego, Calif.* 10½ x 7; 2; 1940 (paper).

NOTES ON SOME NORTH AMERICAN BIRDS OF THE GENERA MYIODYNASTES, PITANGUS, AND MYIOCHANES. *Transactions of the San Diego Society of Natural History, Volume 9, No. 17.*

By A. J. van Rossem. *Society of Natural History, San Diego, Calif.* 10½ x 7; 8; 1940 (paper).

THE WORM SNAKES OF THE GENUS LEPTOTYPHLOPS IN THE UNITED STATES AND NORTHERN MEXICO. *Transactions of the San Diego Society of Natural History, Volume 9, No. 18.*

By Laurence M. Klauber. *Society of Natural History, San Diego, Calif.* 10½ x 7; 76; 1940 (paper).

THE LYRE SNAKES (GENUS TRIMORPHODON) OF THE UNITED STATES. *Transactions of the San Diego Society of Natural History, Volume 9, No. 19.*

By Lawrence M. Klauber. *Society of Natural History, San Diego, Calif.* 10½ x 7; 32; 1940 (paper).

TWO NEW SUBSPECIES OF PHYLLORHYNCHUS, THE LEAF-NOSSED SNAKE, WITH NOTES ON THE GENUS. *Transactions of the San Diego Society of Natural History, Volume 9, No. 20.*

By Lawrence M. Klauber. *Society of Natural History, San Diego, Calif.* 10½ x 7; 20; 1940 (paper).



BOTANY

THE BADIANUS MANUSCRIPT. (*Codex Barberini, Latin 241*) *Vatican Library. An Aztec Herbal of 1552.*

Introduction, Translation and Annotations by Emily Walcott Emmart. With a Foreword by Henry E. Sigerist. The Johns Hopkins Press, Baltimore; Oxford University Press, London. \$7.50. 12 x 9½; xxiv + 341; 1940.

This facsimile of the first medical book of the Western Hemisphere, preceded by a foreword by Henry Sigerist, a lengthy preface on the construction of the manuscript, early knowledge of materia medica, Aztec folklore of medicine, etc., which prepare the reader for the fare that is to come, is indeed a remarkable book. And as one continues on to the end one becomes more and more grateful not only to Dr. Emmart, whose untiring and persistent efforts have made this such a memorable volume, but to all those individuals and groups whose aid, financially and otherwise, have made it possible for such an important and expensive work to be acquired at such a low price. It is a treasure that should be on biological book-shelves and in private libraries, as well as available in public libraries for exhibition purposes.

The original, a little book, 6 inches wide, 8½ inches high, and ½ of an inch thick, bound in crimson velvet, has lain for perhaps three centuries at least in the Vatican Library, its very existence unknown until comparatively recently. On

the first fly-leaf is in Latin the following inscription [we give Emmart's translation]: "A little book of Indian medicinal herbs composed by a certain Indian physician of the College of Santa Cruz, who has no theoretical learning, but is well taught by experience alone. In the year of our Lord Saviour 1552."

In the early period following the Mexican conquest the Spaniards established schools and colleges in order to acquaint the Aztecs (one of the most intelligent of the American Indian races) with European culture; and shortly the students were able to speak fluently in both Spanish and Latin. To instruct them in the art of medicine a native physician, Martinus de la Cruz, was brought to the College of Santa Cruz in Talaltelolco—the first college of higher education to be established in the New World. It was Martinus who wrote the text of this little treatise on Mexican medicinal plants and native remedies. Another native, one of the early students, and later "Reader in Latin" at the college, Juannes Badianus, translated the text into Latin.

A table of contents groups the material into 13 chapters, each dealing with a different group of afflictions which tend to range from the head to the feet. In the treatment and cure of these ailments practically all members of the plant kingdom found in Mexico were used—from small rock plants to large trees; from aquatic to desert forms. Among the most interesting of the native Aztec remedies are the narcotics and analgesics. The 87 pages of plant illustrations have been most skillfully reproduced in the present volume and show the brilliant colors of the original manuscript. It is uncertain whether Martinus or Badianus made the original paintings, but they were beautifully and carefully executed. While they perhaps are inferior in technical detail when compared with the 15th and 16th century herbals of Europe, they compare very favorably with those of the 13th and 14th centuries. As in the European herbals the illustrations are of a constant size regardless of the natural size of the plant.

Following the facsimile are Emmart's transcriptions and translations of the

text with many interesting comments and footnotes and the volume is completed by a group of indices referring to Aztec terms, botanical and animal forms, stones, earths and minerals, materia medica, maladies, and a bibliography of over 60 titles.



THE COMPLETE GUIDE TO SOILLESS GARDENING.

By W. F. Gericke. *Prentice-Hall, New York.* \$2.75. 9 x 6; xvi + 285; 1940.
GARDENING WITHOUT SOIL.

By A. H. Phillips. *Chemical Publishing Co., New York.* \$2.00. 8½ x 5½; 137; 1940.

The last word in hydroponics will undoubtedly not be written until sometime in the far future, but, to date, Gericke's scholarly and authoritatively written volume presents all the worthwhile theories, techniques, hopes, and trends of this relatively new phase of botany. In spite of the fact that the soilless method of rearing plants was known and used in plant physiology laboratories since the middle of the last century, Gericke is recognized as the father of hydroponics, because it was he who first grasped the practical significance of the field and prepared the way for its growing success in competition with regular agriculture.

In addition to the discussions on the methods and materials of hydroponics, Gericke suggests the way for profitable investigation in the future, and makes a strong plea for soilless gardening as one of the answers to the present world economic dilemma. The text is generously supplied with illustrations, and the work is concluded with a useful glossary and a complete index.

The second of these volumes, intended for the British public, includes nothing new or original in the field of soilless gardening. The subject is presented in a brief and exact fashion, by one who has a well-grounded knowledge of the physiology of plant growth, and should prove quite helpful to those who have a few minutes each evening to spend on this interesting and worthwhile phase of botany.

THE EVOLUTION OF THE LAND PLANTS [EMBRYOPHYTES].

By Douglas H. Campbell. *Stanford University Press, Stanford University, Calif.; Oxford University Press, London.* \$6.50. 9 x 6; ix + 731; 1940.

For the trained botanist this book makes most interesting reading.

"Plants are, on the whole, far more conservative than animals, and most of the existing types can be traced back to a very remote period." Close relationships between any two groups can only be found among the simpler forms. "... some of the most successful living plant types retain certain primitive characters." It is the present practice to class all forms below the mosses (bryophytes) in a single subkingdom, yet "the inclusion in a single subkingdom, of such a heterogeneous assemblage of evidently divergent types is decidedly unscientific. . . ." On the other hand, the three groups of higher plants (mosses, ferns, and seed plants) are treated as independent subkingdoms "... although it is generally recognized that these three groups are essentially similar in their reproduction. There is abundant reason for placing these three groups in a single subkingdom, Embryophyta, as is done by Engler."

The essential similarity in the reproduction of embryophytes was demonstrated nearly 80 years ago by Hofmeister, but the old classification has still been retained.

This book is concerned with tracing the relationships among the different members of the embryophytes (the typical green land plants) as well as their relationships with their nearest relatives among the algae. Campbell draws upon an abundance of literature as well as his own researches in reaching his conclusions. The detailed treatment of the subject matter, the documentation of the chapters, the 350 figures almost all of which give several views, and the detailed index give testimony to the care with which the volume has been prepared.



THE SCIENCE AND PRACTICE OF CONSERVATION: *Grass and Forage Crops.* In Two Volumes.

By S. J. Watson. *Fertiliser and Feeding Stuffs Journal, London.* 30s. net. 9½ x 5½; xi + vii + 820; 1939 (paper).

The main object of these volumes is to give a detailed and conservative account of the studies on the conservation of

fodder crops at Jealott's Hill (Jealott's Hill Research Station, Bracknell, Berks, England). In addition, all relevant and important findings, which an examination of the extensive literature from all parts of the world has yielded, have been incorporated. Each of the 23 sections is as complete as it has been possible to make it.

In order to give a general idea of the manner in which the subject matter is arranged we have selected Chapter 13, which is on the losses involved in making silage, and have given the topics around which the discussion takes place: Nature of the losses in silage-making; Measurement of losses; The losses in grass silage; The losses in silage made from legumes, alone or with an admixture of grass; The losses in the ensilage of silage mixtures; The losses in the ensilage of maize and other carbohydrate-rich crops; Comparison of losses in the different groups; Losses of mineral constituents; Loss of vitamins; Conclusions.

The different sections contain much tabular matter and lengthy reference lists and at the end of Volume II are author and subject indexes. An important work.



DESERT WILD FLOWERS.

By Edmund C. Jaeger. *Stanford University Press, Stanford University; Oxford University Press, London.* \$3.50. 8½ x 5½; xii + 322; 1940.

The name of Edmund C. Jaeger on the title page of any volume is adequate certification of its excellence, and this one is worthy of its predecessors. It is to be hoped, however, that it will not be too successful in popularizing the desert, as the vandalous raids made upon this region by Philistines of a nearby metropolis have got past the stage where they are merely a scandal.

There is probably a greater number of species of flowering plants in the Colorado desert than in any other equal area in the United States, and the need for a reliable textbook containing descriptions and illustrations is evident. This is not so much a field-book as a laboratory manual and if specimens are brought into the laboratory

their identification will be greatly facilitated.

The work is amply illustrated by drawings and photographs. The latter are especially worthy of mention. A somewhat unusual but interesting feature is the wealth of biographical material about persons otherwise forgotten, but whose names are perpetuated in those of the plants. These names as well as the names of the plants are included in the six and a half page index.



COMPETITION AMONG GRAINS.

By N. Jasny. *Food Research Institute, Stanford University, Calif.* \$4.00. 8½ x 5½; xiii + 606; 1940.

A work destined to be of great value for reference to all those in any way concerned with grains. The author's extensive experience in Russia, Germany, and the United States, and his familiarity with the literature have well fitted him to produce an authoritative survey. The purpose of the study

is to indicate the major influences responsible for the present distribution of world production and world trade among the individual grains and the major long-run changes in this distribution. To fulfill this task the competitive position of each grain must be studied in the spheres of both consumption and production.

To find space for a rather detailed analysis of both production and marketing phases, the study had to be limited to a few goods only. . . . The term "grain" as here used refers specifically to only five grains: wheat, rye, barley, oats, and corn; and attention is directed principally to the production of these crops for grain rather than for hay, silage, and pasture. The study is furthermore primarily concerned with the occidental parts of the world's temperate zones. Even within this territory, countries not participating in world trade could in general be given only passing attention.

Charts, tables and diagrams exhibit the data effectively and the work concludes with appendix notes and tables and a useful index.



ROCKY MOUNTAIN TREES. *A Handbook of the Native Species with Plates and Distribution Maps.*

By Richard J. Preston, Jr. *Iowa State*

College Press, Ames. \$2.00. 7½ x 5; lxxxi + 285; 1940.

The Rocky Mountain trees for the separate states have been classified in a number of pamphlets but not until the appearance of the present volume have the characteristics of the trees for the entire Rocky Mountain region been gathered into one concise key. Hence this authoritative work fills a real need in the field of forestry.

The text includes discussions of the topography of the Rocky Mountain region as well as the general characteristics of trees. Numerous plates showing the leaf, twig, flower, fruit, and bark of many species, as well as distribution and zone maps, descriptions of botanical and silvical characters, check lists of species by states, and extensive keys, give an indication of the comprehensiveness of the work. The inclusion of all native and naturalized trees of the Rocky Mountain region numbering some 252 species representing 85 genera and 40 families is also indicative of the vast field covered.

A useful glossary, a selected bibliography, and a complete index conclude the volume.



PLANT MICROTECHNIQUE.

By Donald A. Johansen. McGraw-Hill Book Co., New York and London. \$4.50. 9 x 6; xi + 523; 1940.

The author states that "the main purpose of the book is to acquaint the user with the principles and procedures of all phases of botanical microtechnique." He succeeds admirably in 500 pages in giving clear, concise directions for the most usable laboratory methods. The first section describes the standard techniques in detail; the second takes up each phylum separately and discusses the special methods that have been developed for handling its members. There is an extensive bibliography. The author has had experience in his own laboratory with the majority of the procedures given, and has much that is pertinent to say on their applications. He also includes a list of sources for living material as well as for apparatus

and stains. The botanist of any degree will desire access to this book.



RUBBER LATEX.

By Henry P. Stevens and W. H. Stevens. Chemical Publishing Co., New York. \$2.00. 8½ x 5½; 224; 1940.

A study of rubber latex from its source to the various products in which it is utilized. The book contains much information in concise form that should be quite valuable in the laboratories of manufacturers using latex in their products, and who seek to further diversify its application. Data are given on the properties of latex and its composition, also methods of stabilization and manipulation. A chapter is devoted to the process of vulcanization, and subsequent chapters discuss various methods of using latex, and its application in the production of numerous articles. The book further records a long list of British patents applying to its utilization and contains a bibliography comprising books and journals that may be consulted for amplified investigation.



THE HOME BOOK OF TREES AND SHRUBS. *A Layman's Guide to the Design, Planting, and Care of the Home Grounds, with Information on Lawns, Woodlands, Flower Borders, Garden Accessories and the Identification of Trees.*

By J. J. Levison. With an Introduction by Samuel J. Record. Simon and Schuster, New York. \$5.00. 10¾ x 7½; xix + 424; 1940.

This volume will find many enthusiastic readers among amateur gardeners. Specially designed for the layman by a landscape forester of wide experience, it gives the kind of advice most needed by those whose interest in trees and shrubs falls necessarily outside that of the professional. It is a manual and practical guide, giving abundant information on what trees and shrubs to plant under different conditions and in different locations, the propagation and care of these, control of insects and disease, the development and care of

lawns, flower borders, etc. The many beautiful illustrations offer numerous suggestions to the landscapist, and the list of suggested reading is helpful. There is a well-planned index.



HAND-BOOK OF COMMON WATER AND MARSH PLANTS OF INDIA AND BURMA, 1936. *Health Bulletin, No. 24. Malaria Bureau, No. 11.*

By K. Biswas and C. C. Calder. *Manager of Publications, Delhi.* Rs. 2. 12 or 5s. $9\frac{1}{2} \times 6\frac{1}{2}$; xiii + 140 + 6 photographs + 32 plates; 1937.

In order to facilitate the study of the distribution and life history of the parasite-carrying mosquitoes by the officers of the Malaria Survey of India this study of the vegetation and plant associations of tanks, ponds, marshes, etc. has been made. The material is in the form of a handy volume, with a minimum of technical terms, and the keys are so arranged that the principal distinguishing characters come first to notice. A glossary, an index, photographic illustrations, and many line drawings (with detailed explanations) help to make this an extremely useful book for its intended purpose.



MANUAL OF CULTIVATED TREES AND SHRUBS Hardy in North America: Exclusive of the Subtropical and Warmer Temperate Regions. Second Edition Revised and Enlarged.

By Alfred Rehder. *The Macmillan Company, New York.* \$10.50. $8\frac{1}{2} \times 5\frac{1}{2}$; xxx + 996; 1940.

Since the first appearance of this useful reference book thirteen years ago (cf. Q.R.B., Vol. 2, No. 4) many new species and varieties have been introduced into cultivation, new hybrids have appeared, and changes in nomenclature have been made. The present edition has been thoroughly revised and enlarged. In some instances the whole genus has been rewritten. There have been some changes made in the zones of hardiness for plants and a new enlarged map of the zones provided. An invaluable guide to the

horticulturalist and all those interested in trees and shrubs.



MICROBES BY THE MILLION.

By Hugh Nicol. *Penguin Books, Ltd., Harmondsworth, Middlesex, England.* 6d. $7 \times 4\frac{3}{8}$; 247 + 8 plates; 1939 (paper).

Imagine that you are one of a party of twenty, and that you are being addressed . . . in the style I use for the more intelligent parties of visitors who come to Rothamsted [Experimental Station] and spend a quarter of an hour or so in the Bacteriology Department during their tour. . . .

This little volume takes the layman on an excursion, and presents him with directions for experiments with bacteria (harmless ones), which can be tried at home.



BASIC COURSE IN BOTANY. The Foundations of Plant Science.

By Raymond J. Pool. *Ginn and Co., Boston, New York and Chicago.* \$3.75. 9×6 ; v + 654; 1940.

The material in this text is treated from the broad biological point of view. Wherever possible the subject matter is shown in its relation to agriculture, public health, soil conservation, land management, etc. Text figures (541), a lengthy glossary, and detailed index complete the volume. An excellent text for a well-rounded course in botany.



FLORAL MORPHOLOGY: A New Outlook with special reference to the Interpretation of the Gynaeceum. Volume One.

By E. R. Saunders. *Chemical Publishing Co., New York.* \$1.50. $7\frac{1}{2} \times 4\frac{1}{2}$; viii + 132; 1940.

An American edition of a work that appeared in England in 1937 (cf. Q.R.B., Vol. 13, p. 107). Emphasis is laid on the necessity for supplementing observation of external features by a study of the vascular ground plan. Vol. II, which completes the work begun by Vol. I, has now been issued.

MORPHOLOGY

SCHNELLMETHODEN DER KERN- UND CHROMOSOMENUNTERSUCHUNG.

By *Lothar Gütler*. Verlag von Gebrüder Borntraeger, Berlin. RM 1.50. 8 $\frac{1}{2}$ x 5 $\frac{1}{2}$; iv + 27; 1940 (paper).

The writer at the beginning of this monograph points out the difficulties and time consumption attending the older methods of fixation and staining of biological material. The techniques which he treats may be separated into two groups: the aceto-carmin group and the osmic acid group. Carmine dissolved in acetic acid colors intensely the chromatin of the resting nucleus and the chromosomes. The acetic acid acts as a fixative and for this reason the stain is used simultaneously for fixation and coloring. The stain is prepared by mixing 45 parts of acetic acid (conc.) with 55 parts of water (dist.) and to this is added approximately 5 grains of carmine. The solution is weakly heated for $\frac{1}{2}$ to 1 hour. After cooling the solution is filtered. The dye may be modified by using 2 to 3 parts of alcohol (abs.) and 1 part of acetic acid (conc.). In the use of osmic acid as a fixative in connection with the smear procedure a 2 per cent solution of osmic acid is used. The addition of one drop of a 1 per cent chromic acid solution is held to improve the osmic acid solution.

Several modifications and procedures for the use of the foregoing preparations are given. The work contains several illustrations.



GROWTH: A Journal for Studies of Development and Disease. Supplement. First Symposium on Development and Growth.

The Editors of Growth, Dairy Building, Cornell University, Ithaca, N. Y. Subscription \$5.00 per volume annually (outside U. S. and Canada, \$5.50). Single numbers \$2.00. 9 $\frac{1}{2}$ x 6 $\frac{1}{2}$; 111; 1939 (paper).

These proceedings of the first symposium of the Society for Development and Growth aim at the integration of knowledge from several branches of biology toward the solution of this problem. The growth of tissues in cultures has shed light on cell

division, morphogenesis, and differentiation, as described in a contribution by Warren Lewis. Other articles discuss the chemical factors in growth and development, while several geneticists show the status of genes as evocators of developmental processes. Another method of attack is presented by Oscar Schotté in his lucid account of studies on regeneration of tissues. Finally the evidence from differentiation of higher plants is described by Edmund Sinnott. Certainly such synthesis of knowledge in the attack on biological problems cannot fail in the long run to produce valuable results.

ORIGIN AND DEVELOPMENT OF THE LYMPHATIC SYSTEM IN THE OPOSSUM (*Didelphys marsupialis* L. var. *virginiana* Kerr).

By *Arnold A. Zimmermann*. University of Illinois Press, Urbana. \$2.50 (paper); \$3.00 (cloth). 10 $\frac{1}{2}$ x 7 $\frac{1}{2}$; 197; 1940.

This detailed study on the origin and development of the lymphatic system in the opossum refutes the Sabin theory on lymphatic genesis (direct centrifugal outgrowth from the venous endothelium) and confirms the mesenchymal origin of the lymphatic system and its genetic independence of the venous system. In addition, new evidence is offered for the refutation of the theory on the venous origin of the jugular lymph sacs. The author utilized the following material: (1) an extensive Wistar Institute collection of sectioned series of opossum embryos ranging from the 8-somite medullary plate stage to birth; (2) sectioned series (Wistar) of two post-natal stages; (3) pouch-young taken directly from a breeding colony (Wistar); and (4) older pouch-young from biological supply houses. There are many graphic reconstructions, photomicrographs, section drawings, photographs, camera lucida drawings, and anatomical sketches. A bibliography is appended.



THE MECHANISM OF THE HUMAN VOICE.

By *Robert Curry*. Foreword by *Douglas Guthrie*. Longmans, Green and Co., New

York and Toronto. \$3.00. 8 x 5½; ix + 205; 1940.

The studies of speech and hearing possess so many facets that few people have a knowledge sufficiently comprehensive to integrate them. The present book is an attempt to bring together the great body of literature dealing with the anatomy, physiology, and acoustics of voice. It is obvious from the length of the volume that a considerable portion of the available information has been omitted. Recognizing this limitation, the author has made an effort to present the more important aspects and to amplify those which are least adequately treated. In addition to detailed accounts of the structure and action of the vocal mechanism, he reviews the experimental methods and results of speech analysis. Further chapters deal with hearing, speech disorders, and the singing voice. The book will be valuable to scientists and teachers whose work concerns the human voice, especially in view of the extensive bibliography which it contains.



ELEMENTARY MICROTECHNIQUE. Second Edition.

By H. Alan Peacock. Edward Arnold and Co., London; Longmans, Green and Co., New York. \$2.40. 7½ x 4½; viii + 330; 1940.

The value of a book of methods and formulae inexpensive enough to be within the reach of students is evident in the publication of the second edition of this volume. (For review of the first edition, see Q.R.B., II, page 107). The material, including concise discussions of cellular and protoplasmic structure, the principles underlying the use of laboratory instruments, the preparations and uses of stains and media, and even the collection and preservation of living material for study, has been rearranged into a form which the author feels to be more usable. The organization is such that details are easily located. Although the book is intended especially as a text for the beginner, the advanced student will find it a handy working reference.

THE PINEAL ORGAN: The Comparative Anatomy of Median and Lateral Eyes, with special reference to the Origin of the Pineal Body; and a description of the Human Pineal Organ considered from the Clinical and Surgical Standpoints.

By Reginald J. Gladstone and Cecil P. G. Wakeley. The Williams & Wilkins Co., Baltimore. \$10.00. 9½ x 6½; xvi + 528; 1940.

This book is the outcome of a desire to study the pineal body from the broad standpoint of comparative anatomy, and to correlate as far as possible the structural appearance and connections of the mammalian epiphysis with the conflicting views which are held with regard to its origin and functions. The authors hope that the book will be of interest to readers outside as well as within the medical profession and that it will stimulate the study of other organs and systems of the human body from the standpoint of comparative anatomy, in addition to the purely practical aspect. Special care has been taken in selecting and making the numerous illustrations, each of which has an independent explanatory legend. A glossary, bibliography, and an unusually complete index are valuable adjuncts to the book.



THE COMPARATIVE ANATOMY OF THE MAMMARY GLANDS. With special reference to the udder of cattle.

By Charles W. Turner. University Co-operative Store, Columbia, Missouri. \$3.50. 11 x 8; [6] + 377 + 54 plates; 1939 (paper).

The five sections of this manual (an outgrowth of a mimeographed publication in 1933) are as follows: The gross anatomy of the mammary glands of cattle (6 chapters); Microscopic anatomy of the udder of cattle (4 chapters); The comparative anatomy of the mammary gland (5 chapters; Monotremata through the Rodentia); Anatomy of the mammary glands of the hoofed mammals (6 chapters; swine, goat, sheep, horse, elephant, certain marine mammals); The anatomy of the mammary glands of the Primates

(2 chapters; lemurs, monkeys, apes, and man).

The sections contain tabular matter, illustrations, and bibliographies and references for further study. The volume is published by the offset process and spiral bound. It contains 54 full page plates and is indexed.



BUNDY'S ANATOMY AND PHYSIOLOGY. *Seventh Edition.*

Revised and Edited by S. Dana Weeder.

The Blakiston Co., Philadelphia. \$2.75.

9 x 6; ix + 490; 1940.

The fact that this work has gone through seven editions sufficiently attests to its acceptance by the teaching profession. It is a clear, concise treatise dealing with the salient points of human anatomy and physiology. Members of the nursing profession will find the book especially helpful. The author has inserted surgical and clinical notes which are correlated with the subject matter of the text. The many tables and illustrations also add much to the text proper.



L'ANATOMIA COMPARATA NEL QUADRO DELLA BIOLOGIA MODERNA.

By Mario F. Canella. Nicola Zanichelli Editore, Bologna. L. 10. 9 x 5½; xiii +

57; 1937 (paper).

The author begins with the statement that since the beginning of the present century the study of descriptive and comparative anatomy has fallen into discredit, as a biological science, at least in Italy, France, and Germany. The brochure has been prepared in an attempt to rectify this state of affairs, as the author believes that comparative anatomy is, and should be considered, a fundamental part of the biological sciences. His arguments are based on the rôle that a knowledge of comparative anatomy and its techniques play in morphology and physiology. Bibliographical annotations are given.

A TEXTBOOK OF HISTOLOGY. *Eighth Edition.*

By Harvey E. Jordan. D. Appleton-Century Co., New York and London.

\$7.00. 9½ x 6½; ix + 690; 1940.

This excellent text has become well known since its first appearance in 1916. The present edition (6th edition noticed in Q.R.B., Vol. 6, p. 242) has been thoroughly revised, and the chapter on blood has been completely rewritten. The chapters on technique and laboratory work have been omitted, since the author feels that most teachers now prefer to write their own working directions. The bibliography has been reassembled to include all of the more important publications of recent years.



REPRODUCTION AMONG MAMMALS. *A Guide for Use with the Instructional Sound Film "Reproduction among Mammals."*

Prepared by Melvin Brodshaug and Frederick T. Howard, in collaboration with Herluf H. Strandkov. University of Chicago Press, Chicago. 15 cents. 7½ x 5½; iv + 26; 1940 (paper).

This 26-page pamphlet contains the script of the Erpi instructional sound film of the same title, with a few introductory notes and a bibliography. Several diagrams from the film are included with the text. The language is simple, and the story concise and complete. The film is one of those used in the large freshman survey courses at the University of Chicago.



PHYSIOLOGY AND PATHOLOGY

THE ENGLISHMAN'S FOOD. *A History of Five Centuries of English Diet.*

By J. C. Drummond and Anne Wilbraham. Jonathan Cape, London. 12s. 6d. net.

8½ x 5½; 574 + 16 plates; 1939.

An extraordinarily interesting book that both the general reader and the food expert will enjoy. The authors (senior author, Professor of Bio-Chemistry in University College) have quite sensibly allowed the technical treatment of the subject to be overshadowed by the his-

torical. Yet the historical is made all the more interesting by being interpreted by specialists. From many different angles the changing character of the English diet during the past five centuries is discussed. It is the bearing which the social and economic conditions have had upon these changes—indeed, the interrelationships of many different factors—that makes this a fascinating book.

Meat, game, and fish formed the main fare in the early days. Since keeping live stock through the winter months was little understood, all but the young and vigorous were slaughtered and dried or pickled for winter consumption. The pigeon-loft furnished fresh meat for the well-to-do; and, of course, game was procurable. As early as the 13th and 14th centuries regulations were formulated prohibiting the cookshops from selling to the poorer classes pies made from tainted meat. Spices were used by all classes either to disguise the strong flavor of meat, or to pep up its insipid taste. Fish, mostly salted and not always when it was exactly fresh, was abundant. Oysters in 1491, were sold for 4 d. a bushel. There are few references to vegetables and fruits in the literature. Cabbage was only used in soups; salads of onions and herbs were popular. Vegetables were supposed to engender wind and melancholy. Butter, by the upper classes was thought only fit to be used in cooking; the poorer classes used it more widely. All classes used a great deal of cheese.

The authors quote freely from the literature throughout the five-century period—from Arthur Young, Pepys, Defoe, Parson Woodforde, Smollett, Burton, André Simon, John Grove, and many others. Among the many topics discussed are changes in physical conditions of the different classes, changing medical views, scurvy, food adulteration, hospital, prison and workhouse diets, food distribution, and finally the great changes in dietetics which have been gradually taking place since the turn of the last century. Scattered throughout the book are illustrations reproduced from different sources. We particularly like the reproduction of the frontispiece from *The Family Oracle of*

Health (opposite page 396) where Dr. Kitchiner is about to be arrested "for eating live oysters and thereby contravening Martin's Bill for the Prevention of Cruelty to Animals."



ACCEPTED FOODS *and Their Nutritional Significance. Containing Descriptions of the Products Which Stand Accepted by the Council on Foods of the American Medical Association on September 1, 1939.*

Council on Foods of the American Medical Association, Chicago. \$2.00. 8½ x 5½; xx + 492; 1939.

The question of the nutritional value of foods is deservedly occupying the attention of those qualified to express an opinion upon it, and this book is a compilation of results attained by the Council on Foods, working under the sponsorship of the American Medical Association. The Council has done excellent work in assembling information on the formulae, vitamin content, chemical analysis, calories, and methods of assembly and treatment of the various food products offered to the public by a goodly number of manufacturers and distributors. It also passes judgment on the nutritional and health claims set forth in the advertising matter that is used to further the sale of different foods. Those organizations, whose products and advertising matter have been passed as satisfactory, are allowed to use the "Seal of Acceptance" as an evidence that their products and advertising matter meet the requirements of the Council. The book contains the names of numerous manufacturers and business houses who have applied for approval of their wares and have had them accepted, but it is noticeable that there are a large number of well-known high grade articles that have presumably not been presented to the Council for acceptance, and one wonders whether the use of the Seal of Acceptance on advertising matter might gradually create a condition of public mind that would be unfair to companies or individuals who have not presented their products for approval, and who might determine, for reasons

satisfactory to themselves, not to ask for this approval. While the immense amount of work done by the Council on Foods is appreciated at its true value, it would seem to have been wiser to have examined and passed on all manufactured and assembled food products, rather than to leave it to individuals to apply to the Council for its approval. As the procedure stands now, in less responsible hands it might conceivably be called a racket.



DYNAMICS OF INFLAMMATION. *An Inquiry into the Mechanism of Infectious Processes.*

By Valy Menkin. The Macmillan Co., New York. \$4.50. 8½ x 5¾; xii + 244; 1940.

The author has recorded and considered in the light of his own experience observations pertaining to "the disturbed physiological and biochemical equilibria occurring in an area of acute injury." The outstanding phases of inflammation, in order of development, are: (a) increased fluid passage through the capillary endothelial wall, which seems to have two primary factors, elevation in capillary pressure and increased capillary permeability; (b) localization or fixation of the irritant, that is, walling-off of the inflamed area; and (c) migration of leucocytes. The relations between the physical basis of infectious processes and immunity in the organism as a whole have led to the formulation of a dynamic concept of inflammation. Leukotaxine, a crystalline nitrogenous substance released by injured tissue, apparently is concerned with both the migration of leucocytes and the increased capillary permeability. In turn the number and kind of leucocytes which are present influence the rate of metabolism and the hydrogen-ion concentration of the inflamed area. Thus a highly complex mechanism which tends to localize and dispose of a bacterial or chemical irritant is put into action when inflammation sets in. This concept gives a rational interpretation to the rôle of inflammation in immunity.

The author indicates several general

lines for further study. Much more work, particularly of a quantitative sort, is certainly needed to clarify the interrelationships of the many factors involved in inflammation.



LIVING LIGHT.

By E. Newton Harvey. Princeton University Press, Princeton. \$4.00. 9 x 6; xv + 328; 1940.

To the unspecialized devotee of natural science perhaps the most mysterious phenomenon of nature is that of luminescence. The flashing of fire-flies on a summer evening over a cultivated lawn, or the display of *Medusae* a month later in the ocean, is a familiar sight, yet familiarity in this instance does not breed contempt. When mankind needs artificial light he obtains it from the combustion of material—a wasteful process, but necessary to one who has not learned the secret of luminescence—the production of light without heat.

The greater complexity of living light makes essential a certain amount of knowledge of other forms of luminescence and illumination. A great part of the book is devoted to the experiments of the physicists and chemists of earlier days, such as Boyle, Lavoisier, and Newton. The entire animal and plant kingdoms are then reviewed, as well as experiments upon them, the bibliography of which covers twenty-nine pages with about twenty entries on each page. Organic light is then discussed as to its physics, chemistry, physiology, intensity, efficiency, and color. An idea of the completeness of this discussion may be gained from the fact that the mysterious N-rays, that caused a furore a generation ago, are included. These mythical radiations have no existence whatever; Harvey generously attributes them to an error in technique of the investigator who announced them prematurely. (But when this announcement was made there were many who believed that a deliberate fraud had been perpetrated.)

There are seventeen pages of index, and many excellent illustrations, both photographs and drawings.

PHYSIQUE AND NUTRITION. *A Study of European School Children in Pretoria, Union of South Africa.* South African Council for Educational and Social Research Series No. 13.

By Harding Le Riche. South African Council for Educational and Social Research, Pretoria. (Copies Obtainable from J. L. Schaik, Pretoria). 8½ x 5½; vi + 158; 1940 (paper).

This monograph contains, besides a discussion of methods of studying the nutritional status of a population, the report of an investigation on the frequency of malnutrition in Pretoria (Transvaal) white school children and of an inquiry into the food consumption of a sample of poor families. The author recognizes that the clinical evaluation of malnutrition by visual inspection can be unreliable and prefers to use the more objective A.C.H. index. On the basis of this he finds that between poor and well-to-do children the differences in frequency of malnutrition are not conclusive, that more boys than girls are malnourished, and that the occurrence of malnutrition increases with age. The author's implicit faith in the A.C.H. index is rather surprising since the postulated relationship of this index to nutritional status is not yet accepted. Furthermore, from the author's data it appears that, as many others have shown, the well-to-do children are on the average larger than the poorer children. An examination of the food consumption of poor families reveals below average intake of all the principal food elements. Although the findings reported here are interesting for comparative purposes their evaluation contributes little to the general problem of physique and nutrition.



HEALTH IS WEALTH.

By Paul de Kruif. Harcourt, Brace and Co., New York. \$2.00. 8 x 5½; ix + 246; 1940.

During a conversation on public health problems between the author and a group of physician friends one evening in 1934, they arrived at the realization that an ounce of prevention being worth a pound of cure to the community could actually be expressed in monetary terms. With

admirable faith and ardor they set about to inform the general public of this fact and consequently to formulate a health program of national scope. The main features of this program which apparently won the approval of conservative members of the American Medical Association as well as that of the Surgeon General are: (1) that under the supervision of the U. S. Public Health Service federal aid should be granted to the states for the care of the "medically" indigent; and (2) that once having satisfied certain minimum requirements, the states should be free in the matter of administration of the funds received. Having succeeded in formulating this "non-controversial" program after five years of labor it remained only to receive the presidential blessing and support. In December, 1939, the president consented to receive de Kruif, as spokesman for the group, and to listen to his proposal. Strangely enough, it turned out that notwithstanding his apparent solicitousness for national welfare Mr. Roosevelt was not interested. So the hopes of the author and his co-workers were shattered. This account of the gradual evolution and crystallization of the idea and its popularization through the medium of the author's articles is written with the usual verve that characterizes de Kruif's works.



BLOOD GROUPS. Reprinted from *Tabulae Biologicae, Volumen 17, Pars 2.*

By William C. Boyd. W. Junk, den Haag. 9½ x 7; 138 + 2 folding plates; 1939 (paper).

The basic facts about blood groups are here presented insofar as possible in tabular form with a minimal amount of text. The first half of the material contains data on the determination of blood groups and on the medico-legal and therapeutic significance of such determinations. Information concerning the chemical and serological nature of the human blood agglutinogens and their relations to those of other species, as well as data on the problem of inheritance of blood groups in man, is presented. The second or anthropological section consists

of tables giving the results obtained by many workers from studies on the frequency of the blood groups and the blood types in various countries, and ethnic groups throughout the world. Maps showing the geographical variations in the frequencies of the blood-group genes, as calculated according to the Bernstein theory from the available data, are included. An enormous quantity of pertinent information has here been condensed into a relatively small space. The bibliography is comprehensive.



EPIDEMIOLOGY IN COUNTRY PRACTICE.

By William N. Pickles. With preface by Major Greenwood. Williams & Wilkins Co., Baltimore. \$2.50. 8½ x 5½; viii + 110; 1939.

The complexity of urban life makes it almost impossible to trace an epidemic to its source, while the comparative simplicity of life in rural communities increases the likelihood of finding not only the most recent contacts but the original source of infection as well. The opportunity for the study of infectious diseases in rural areas is well presented in this book. The author is an English country doctor who has published a number of papers on epidemiology. What he has done shows what could be gained by encouraging similar efforts among doctors in the less densely populated regions.

The author points out that, judging from his own experience, epidemiological records collected from many rural practitioners might noticeably modify our ideas on incubation time and duration of infectivity. His studies suggest a program of research that requires neither a big hospital nor a laboratory. The usefulness of such collections of records is easily apparent.



ANNUAL REVIEW OF PHYSIOLOGY. Volume II.

Edited by James M. Luck and Victor E. Hall. Annual Reviews, Inc., Stanford

University P. O., Calif. \$5.00. 8½ x 6; vii + 501; 1940.

Those of us who find that the best way of keeping in touch with current literature is to make use of review journals, at least for fields other than our own research specialties, will welcome the *Annual Review of Physiology*. Continuing the good work done in the first volume (1939), the editorial committee has again brought together a number of authoritative articles on some of the more actively investigated phases of physiology. Typical articles are those on the Lymphatic system, the Central nervous system, the Pharmacology of barbiturates, and Exercise. All of the articles are fine examples of critical survey. To review each paper separately would be impossible here. It must suffice to say that each is a well-rounded account of the subject which it discusses. The list of references given at the end of each paper is invaluable to anyone who wishes to pursue the subject further. There is also an author and a subject index for the volume.



MORPHINE ADDICTION IN CHIMPANZEES. *Comparative Psychology Monographs. Volume 15, Number 7. Series No. 79.*

By S. D. S. Spragg. The Johns Hopkins Press, Baltimore. \$1.75. 10 x 6½; 132; 1940 (paper).

In this monograph are published the results of an investigation on the nature of morphine addiction in chimpanzees, a species of the anthropoid apes chosen for their close resemblance in behavioral capacities to man, and high degree of intelligent cooperation in experimental procedures. The results of the experiments on morphinism in chimpanzees were compared to functional changes reported in clinical data on morphinism in man. The experiments were carried out on four young chimpanzees (3 males and 1 female) with dosage periods differing for each animal—13 months, 7 months, 4 months, and 6 weeks. During the period of drug administration physiological and behavioral functions in pre-dosage, post-dosage, and "withdrawal" periods were studied, and these results compared with the normal functions in

pre-morphine studies on the same four infrahuman organisms. This type of investigation is of great practical importance in the study of drug addiction in man. Tables, graphs, photographs, and references are included.



THE HEALTH OF THE CHINESE IN AN AMERICAN CITY. *San Francisco.*

By J. C. Geiger, Emmett E. Sappington, Roslyn C. Miller, and Hilda F. Welke. Department of Public Health, San Francisco. 8½ x 5½; 29; 1939 (paper).

This study of the health of the Chinese population of San Francisco is interesting from both the medical and biological standpoint. The general history shown indicates a decidedly bad housing situation, and this, with a probable inclination to resist medical attention and advice, has in the past resulted in unfavorable differences between the Chinese health records and that of the general population. However, over a ten-year period (1929-1938) we find the Chinese death rate sinking below that of the general population, and a remarkable decrease in infant mortality, due partly no doubt to education of Chinese mothers in modern methods of caring for infants. The numerous statistical tables presented and the studies of the effect of environment and national characteristics, which furnish data as to Chinese susceptibility or resistance to various diseases, will be of value to biologists engaged in studies along these lines.



MODERN DIABETIC CARE: *Including Instructions in the Diet and the Use of the Old and New Insulins.*

By Herbert Pollack. Harcourt, Brace and Co., New York. \$2.00. 8 x 5½; viii + 214 + 4 plates; 1940.

It is rather obvious that in the care and treatment of diabetes mellitus some accumulation of knowledge, by the affected individual, of the causes leading to this disease and a clearer understanding of his physical reactions to its effects, would help considerably in its control, especially

when aided by the observations and advice of an intelligent physician. This work is eminently fitted to furnish the diabetic layman with the requisite information, and is couched in language easily understood. The book treats of the causes of diabetes and the most advanced methods of its treatment, and also furnishes a very complete study of diabetic dietetics, in which part Marie V. Kraus is co-author. Physicians can undoubtedly use this publication to advantage and biologists will find information which will possibly be useful in some fields of research—probably in the study of heredity, where in many instances the question is as yet an open one.



DERMATOLOGIC THERAPY IN GENERAL PRACTICE.

By Marion B. Sulzberger and Jack Wolf. The Year Book Publishers, Chicago. \$4.50. 8 x 5½; 680; 1940.

This exhaustive text embodies a clearly-written, easily-understood, and precise treatise in which are detailed only those elements of the management of the "commoner" skin diseases and syphilis which will prove practical and useful to every physician. The objective of the book, therefore, is to describe as fully and completely as possible those procedures and medicaments which every physician can promptly apply. The authors are to be commended especially on their judicious selection of topics. This compact "work-bench" of dermatology puts the necessary tools in the physician's hands and tells him exactly how to use them to best advantage. Points of special value to note are: 266 tried and proved prescriptions, group photographs to simplify differential diagnosis, step-by-step directions, immediately usable techniques, and time-saving tables and summaries. The volume is indexed and plentifully supplied with illustrations and lists of further references.



A COLLEGE TEXTBOOK OF HYGIENE. *Third Edition.*

By Dean Franklin Smiley and Adrian G.

Gould. *The Macmillan Co., New York.*
\$2.50. 8½ x 5½; xiii + 539; 1940.

The earlier editions of this widely-used textbook were reviewed in Vol. 3, p. 590, and in Vol. 10, p. 239. Although the student will still find the subject matter classified under thirteen section headings mostly based upon the various systems of the body, he will note that in this edition for the first time many of the community health problems are discussed in direct association with the presentation of the personal hygiene material. Outstanding changes in the personal hygiene subject matter include a discussion of pneumonia, a new chapter on air conditioning and ventilation, a discussion of appendicitis, and a new chapter on the use of medical services. Bibliographies and references are appended to each chapter. In the appendix the prone pressure method of artificial respiration is given in detail. A glossary of technical terms and an index complete the book.



MÉDICAMENTS ANTIANÉMIQUES ET ANÉMIES EXPÉRIMENTALES.

By Jean Chreymol. Preface by René Hazard. *Masson et Cie, Paris.* 50 cents.
8 x 5½; [4] + 101; 1940 (paper).

Despite the fact that anemias are among the oldest recognized ailments of mankind, it is only within recent years that any progress has been made in their treatment. The multitude of factors which are involved make these afflictions particularly difficult to study. In this as in other diseases, one of the most fruitful and promising methods of attack is by experimentation on lower animals and application of the results, as far as possible, to man. The initial section of this book discusses mainly the experiments of Whipple, Castle, Minot, and Murphy on the treatment of pernicious anemias by various extracts. The remaining pages describe the experimental introduction of anemias in laboratory animals and the testing of antianemic medication in these diseased forms. This small volume is an excellent compendium of the patient research which thus far has met with only partial success,

but holds promise for the future. There is a bibliography of 248 titles.



THE STORY OF DENTISTRY: from the Dawn of Civilization to the Present.

By M. D. K. Bremner. *Dental Items of Interest Publishing Co., Brooklyn, N. Y.; Henry Kimpton's Medical House, London.*
\$3.75. 9½ x 6½; xix + 211; 1939.

In presenting this unpretentious volume the author makes no claims of originality, but he has obviously accomplished much in compiling this first "complete-in-one-volume" history of dentistry from pre-historic times to the present. This is the first time, also, that dental history has been treated in its relationship to the social and cultural environment. The book is written for the rank and file and not for the chosen few. However, although the story is told in lighter vein, there has been no deviation from the facts as found in the original sources. The simple, nontechnical style of *The Story of Dentistry* recommends it to every intelligent reader who will find much of interest and value between its covers. The volume is supplied with a complete index and is illustrated with photographs and brief biographical sketches of outstanding leaders of the dental profession through the years.



THE FUNDAMENTALS OF PERSONAL HYGIENE: Including Their Practical Application to Healthful Living. Third Edition, Revised.

By Walter W. Krueger. *W. B. Saunders Co., Philadelphia and London.* \$1.75.
7½ x 5½; xiv + 304; 1940.

In this revision, the subject matter has been brought abreast of the advancing field of hygiene and altered in other respects to increase its value. Additions and changes have been made on such subjects as the feet, posture, care of the skin, nutritional needs and hygiene, venereal diseases, health fads, the common cold, and tuberculosis. Some of the illustrations have been replaced by new

ones and their total number has been increased. Especially helpful and timely is the excellent chapter on mental health.



DIABETES MELLITUS AND THE JEWISH RACE.

By Ernst Lyon. Ludwig Mayer, Jerusalem. 8½ x 5½; 32; 1940 (paper).

The question as to whether the Jews are more susceptible to diabetes than other races is here presented in an interesting discussion of the subject. The numerous statistical references presented would seem to indicate that Jews, especially in the older age groups, do show a greater percentage of diabetes than other races do, but whether it is a hereditary racial weakness or is due to possible environmental factors is not reasoned out to a definite end. It is quite evident that only continued biological study can eventually answer the question. A reading of this book will furnish some facts useful in further research on the subject.



BIBLIOGRAPHY OF REFERENCES TO THE LITERATURE ON THE MINOR ELEMENTS AND THEIR RELATION TO PLANT AND ANIMAL NUTRITION. First Supplement to the Third Edition.

Originally compiled by L. G. Willis. Chilean Nitrate Educational Bureau, New York. Free. 11 x 8½; 82; 1940 (paper).

BOTANICAL INDEX TO THE THIRD EDITION OF BIBLIOGRAPHY OF REFERENCES TO THE LITERATURE ON THE MINOR ELEMENTS AND THEIR RELATION TO PLANT AND ANIMAL NUTRITION.

Chilean Nitrate Educational Bureau, New York. Free. 11 x 8½; 24; 1940 (paper). Instead of complete editions of this important *Bibliography* (cf. third edition, Q.R.B., Vol. 14, p. 491) being prepared as new material accumulates, it is the plan to issue, at approximately yearly intervals, supplements to the third edition which will bring the work up to date. To the indices, which are extremely useful, has been added a botanical index. In order that this index be complete a botanical index to the third edition has also been issued.

TRAITÉ DE LA TRANSFUSION SANGUINE.

By G. Jeanneney and G. Ringenbach. Masson et Cie, Paris. \$2.50. 10 x 6½; [4] + 386; 1940 (paper).

Drawing from the literature and their own extensive experience, the authors have included: history of the administration of blood transfusions from antiquity to the present time; indications and results; contra-indications; immuno- and cata-phylactic transfusions; choice of donor; anticoagulants; preservation of blood for transfusions at a later time; technique and apparatus; accidents during and after the administration, their causes and treatment; modes of action and behavior of transfusion; organization of blood transfusion centers, including those of the battlefield; and special problems of technique, medico-legal aspects, etc. The bibliography, arranged by subjects, covers 19 pages. The book is illustrated.



MALNUTRITION IN SOUTH AFRICA.

By Ellen M. Radloff and T. W. B. Osborn. The Witwatersrand University Press, Johannesburg. 2s. 10½ x 9; [2] + 29 + 4 tables; 1939 (paper).

Although a few pages of this book are devoted to dietary deficiencies in South Africa, in the main it discusses malnutrition generally. In Africa, as in other parts of the world, the problem is not that the people fail to get a sufficient quantity of food, but the proper chemical and vitamin constituents are lacking. The first section of the book outlines the principal dietary essentials, following which is a comparison of several South African diets to what may be considered a normal allowance. A number of suggestions are offered as to the methods by which malnutrition might be remedied.



LA SÉNESCENCE ET LE RAJEUNISSEMENT. Traduction libre de l'allemand.

By Paul Niehans. Vigot Frères, Paris. 8½ x 6; 72; 1937 (paper).

Only a third of this book treats the processes of human senescence; the rest is devoted to an exposition of the various methods

for rejuvenation propounded by Voronoff, Steinach, Slotopolsky, the present author, and others, and the advocacy of the use of the different methods (hormone treatment, glandular transplants and grafts, ligation, etc.) according to the various indications. The author concludes with a plea that physicians concentrate their efforts as much toward combating the discomforts of old age as they do to combating disease. The work is a translation from the German. It has no bibliography.



BIOCHEMISTRY

BIOCHEMISTRY OF DISEASE.

By Meyer Bodansky and Oscar Bodansky.
The Macmillan Co., New York. \$8.00.
9 $\frac{1}{2}$ x 6 $\frac{1}{2}$; viii + 684; 1940.

The increasingly important position of biochemistry in medicine makes this a book of exceptional interest to all who deal with man's ills. In many instances the difference between normal and pathological conditions in the human body is very slight. Frequently an altered biochemical reaction is one of the earliest indications of disorder, and in almost every disease the biochemist's report is an important part of the case history. In this book the authors have brought together the latest biochemical information on many diseases. The viewpoint is that of the clinician. Laboratory techniques are included only when the coöperation of the physician is necessary to complete the test. Practical applications of recent research are given in full. In order to make specific details more readily available to the busy medical man the material is divided into sections on the various organs and organ systems, and on such general topics as disorders of nutrition, and metabolism, and the biochemical aspects of neurologic and psychiatric disorders.



TRAITÉ DE CHIMIE ORGANIQUE. Tome VI. Glycols, Glycérols et Alcools Polyvalents Supérieurs, Phénols et Polyphénols, Phénols-Alcools, Dérivés Sulfurés, Séléniés ou Tellurés Correspondants aux Alcools ou aux

Phénols, Développateurs Photographiques Organiques, Industries des Phénols.

By J. Amiel, P. Baud, R. Delaby, G. Laude, P. Pascal, Ch. Prévost, A. Seyewitz and M. Tiffeneau. Published under the Direction of Victor Grignard, G. Dupont, R. Locquin and Paul Baud. Masson et Cie, Paris. \$8.45 (paper); \$9.10 (cloth). 9 $\frac{1}{2}$ x 6 $\frac{1}{2}$; xix + 1182; 1940.

TRAITÉ DE CHIMIE ORGANIQUE. Tome IX. Monoacides, Éthers-Sels, Industries des Produits Acériques et des Produits Méthylliques.

By J. Aboulenc, J. Lichtenberger, J. B. Senderens and R. Trucbet. Published under the Direction of Victor Grignard, G. Dupont, R. Locquin and Paul Baud. Masson et Cie, Paris. \$6.25 (paper); \$6.85 (cloth). 9 $\frac{1}{2}$ x 6 $\frac{1}{2}$; xix + 831; 1940.

These are the sixth and ninth volumes of an extensive set. The high standards which mark the preceding works reviewed in this journal have been maintained throughout the present pages. Each volume is thoroughly indexed and contains complete bibliographies on the various subjects which are listed in the titles above.



ANNUAL REVIEW OF BIOCHEMISTRY. Volume IX.

Edited by James M. Luck and James H. C. Smith. Annual Reviews, Stanford University P.O., Calif. \$5.00. 8 $\frac{1}{2}$ x 6; ix + 744; 1940.

In spite of the many difficulties under which the present volume has been prepared—foreign contributors working under adverse conditions, material lost or delayed in the mails, etc.—this volume maintains the high standard of its companions and presents many interesting sections. We always regret that the limited space available prohibits a detailed review. As usual, it is only possible to list a few papers and we have selected for this occasion those of special interest to the general biologist: Plant pigments, by G. Mackinney; Aspects of inorganic metabolism in plants, by C. B. Lipman; Soil microbiology, by S. A. Waksman; Organic acids of plants, by H. B. Vickery and G. W. Pucher; Biochemistry of the lower fungi, by H.

Raistrick; Insect biochemistry, by R. Craig and W. M. Hoskins; Application of radioactive indicators in biology, by G. Hevesy.

The extent of the total documentation of the volume is indicated by the length of the author index. This covers 27½ pages, many of the names being followed by several page references. The subject index covers 26 pages, and again, many subjects have more than one page reference.



DIE METHODEN DER FERMENTFORSCHUNG.
Lieferung 1.

Edited by Eugen Bamann and Karl Myrbäck. Georg Thieme Verlag, Leipzig.

R.M. 18. 11 x 8; ix + 172; 1940 (paper).

This is the first number of an important, comprehensive work on the enzymes, with an international list of contributors, which will ultimately comprise about 3,500 pages. The present number treats the substrates (substrates of ester splitting enzymes and part of the material on the biologically important carbohydrates and glycosides). A bibliography of 6,000 titles to the completed work is promised.



UNIVERSITY OF COLORADO STUDIES. Series D. Physical and Biological Sciences, Volume 1, Number 1. A Group of Papers from the Department of Chemistry.

University of Colorado, Boulder, Colorado.
\$1.00. 10 x 6½; 69; 1940 (paper).



SEX

TRANSITION YEARS. *The Modern Approach to 'the Change' in Womanhood.*

By Joseph Rety. Greenberg, Publisher, New York. \$1.75. 8 x 5½; 168; 1940.

The author, a gynecologist of four decades of experience, has written a straightforward account of the climacteric, the "change of life" in woman, and the concomitant alterations in mental and physical makeup. These latter changes, especially mental, need not be at all disturbing, but due to faulty knowledge and ignorance this period is looked upon with

acute fear by many women. The author points out that fear is one of the most serious problems of the climacteric. "All others can be dealt with by simple means as diet, exercise, self-control and, where necessary, an up-to-date medication." There is a general outline covering the physical and psychological "troubles" which may accompany the change, the symptoms of such troubles, their relation to the climacteric, and the treatment of these ailments—especially the use of ovarian and thyroid extracts. This account, addressed to all women and written mainly in narrative style, presents an excellent and unalarming survey of the period which so many women face and undergo with unnecessary fear.



YOUR MARRIAGE: A Guide to Happiness.

By Norman E. Himes. Farrar and Rinehart, New York and Toronto. \$3.75.

8½ x 5½; xiv + 434; 1940.

Most books on sex and marriage within recent years have taken an extremist viewpoint. The writers have been either zealous reformers or advocates of free love. It is some consolation occasionally to find a book, such as this, which is entirely rational and will serve as a guide to young people. Although the author discusses the sexual and reproductive aspects of marriage, large portions of the volume are devoted to social and economic factors. Of particular value are the sections dealing with consumer guidance, budgets, insurance, credit, and buying or renting a home.

The author favors earlier marriages as a solution to several present day problems, particularly to those resulting from premarital sexual tension. However, early marriages introduce other problems perhaps equally serious. Many people will disagree with this and other viewpoints expressed throughout this volume, but by and large it should prove to be a most useful guide.



SEXUAL DISORDERS IN THE MALE.

By Kenneth Walker and Eric B. Strauss.

With a Foreword by Sir Walter Langdon-

Brown. Williams & Wilkins Co., Baltimore. \$3.00. 8½ x 5½; xiv + 248; 1939.

This book is offered as a practical manual for the general practitioner and the medical student. In it the common male sexual disorders are discussed from the point of view of diagnosis and practical treatment. Both psychological and physical underlying factors are considered, the former being recognized as the most frequent etiologically. It is unfortunate, therefore, that the book is able to give so little real understanding of how the psychological aspect is to be handled, and that so much space is devoted to descriptions of physical measures. There is a list of references and an index.



SEX IN MARRIAGE.

By Ernest R. Groves and Gladys H. Groves. Emerson Books, New York. \$2.00. 7½ x 5; 250; 1940.

This is not "just another sex book." The senior author, Professor of Sociology at the University of North Carolina, has long been a serious student of the problems of family life—to him is credited the first college course dealing with such questions. Mrs. Groves has ably assisted her husband in his work. In general, this edition differs little from the earlier one which was written "to give briefly and clearly information which an experience of twenty years in dealing with family problems has led the authors to think most useful in helping young people meet the sex demands of marriage."



BIOMETRY

ELEMENTI PER UNA TEORIA MATEMATICA DEL CONTAGIO.

By Marcello Puma. Editoriale Aeronautica, Roma. L. 13. 7½ x 5; 200 + 9 folding charts; 1939 (paper).

The well-known differential equation of growth is developed here and applied to the spread of contagion in a collectivity. The author examines briefly the modifications of the general equation depending

upon the conditions postulated, such as, a closed or open community; immune, partially immune, or non-immune populations; direct or indirect contagion, etc. Although theoretical and elementary, this book outlines very clearly the fundamental concepts of a mathematical treatment of epidemics.



INTRODUCTION TO MEDICAL BIOMETRY AND STATISTICS. *Third Edition, Revised and Enlarged.*

By Raymond Pearl. W. B. Saunders Co., Philadelphia and London. \$7.00. 9½ x 6½; xv + 537; 1940.

This edition of a widely used text has been extensively revised. Material that the general progress of the subject has rendered no longer useful has been omitted, giving space for new matter. Many new illustrations and tables have been added, and also a new chapter on the measurement of variation. Altogether the book has been increased in size by nearly 80 pages.



THE BULLETIN OF MATHEMATICAL BIOPHYSICS. *Volume 2, Number 4, December, 1940.*

Edited by N. Rashevsky. Editorial and Publication Offices, 5822 Drexel Avenue, Chicago.

This number contains the following papers: Some general theorems of the motion of incompressible viscous fluids, by G. Young; A neural mechanism for discrimination III. Visually perceived lengths and distances, by A. S. Householder; Deformation of shell shaped cellular aggregates; Application to gastrulation, by N. Rashevsky; Some considerations on mathematical molecular biophysics, by N. Rashevsky; Index for Volume 2.



PSYCHOLOGY AND BEHAVIOR

EXPLORATIONS IN PERSONALITY. *A Clinical and Experimental Study of Fifty Men of College Age. Harvard Psychological Clinic.*
By Henry A. Murray. Oxford University

Press, New York, London and Toronto.

\$8.50. 9½ x 6½; xiv + 761; 1938.

This book presents a detailed and technical account of the most original, thoroughgoing, and systematic attempt at a consistently scientific appraisal and understanding of human personality that has yet been made. It is a collaborative effort of a group of persons, in respect of both the observational and experimental work upon which the account is based, and the actual writing of the book. But to Murray, the planner, director, analyst, and synthesizer of the investigation clearly belongs the major part of the credit for the success and significance of the outcome. The studies were made on 51 male subjects of college age. Eleven were drawn from the ranks of the unemployed. The remainder were students, all chosen by the Harvard Employment Office, with equal representation of high and low scholarship, and paid the current wage for their service as subjects. They were "normal" persons, in the usual and conventional sense that they had not been regarded as, or accused of being, either more or less crazy than the general run of mankind.

These subjects were put through a series of carefully and thoroughly planned examinations, experiments, interviews, and tests widely ranging in their comprehensiveness. It is safe to say that no such number of "normal" human beings have ever been so thoroughly and completely studied in respect of their total personalities as these were.

The primary purpose of the study was methodological, and in this respect the net result is of first rate importance. A methodology has been developed that, even though far from being yet perfected, will yield rich and novel rewards to the psychologist and psychiatrist if it is consistently and intelligently employed. Specifically in the present case it has yielded a composite picture of the present day individual of college age that is clear-cut and illuminating within its defined boundaries.

The book is so packed with technical detail in both its theoretical and objective aspects as to make any summary of findings impossible in the space here available.

But every student of human biology, whatever his special field of interest, will wish to read and study it. For it is a contribution belonging in the absolutely first rank of significance. There is included at the end a glossary of terms used, which the reader will find extremely useful, and a competent index.



SOCIAL AND BIOLOGICAL ASPECTS OF MENTAL DISEASE.

By Benjamin Malzberg. State Hospitals Press, Utica, N. Y. \$2.50. 9½ x 6½; 360; 1940.

This very interesting statistical survey is based on standardized data recorded on patients with mental disease in New York State since 1890. In the first chapter the trends of mental disease in New York State are investigated, and the general conclusion reached that a relative increase in such diseases exists. It is noted that this does not necessarily imply an increase in the number of defective family stocks, but is consistent with the degree and rapidity of social changes which have occurred in recent generations—a constructive viewpoint for mental hygiene. In the second chapter the relationship between age and mental disease is considered. It is pointed out that the natural sequence of mental diseases through the different age periods—dementia praecox and manic-depressive psychoses in the early periods of life, general paresis and alcoholic psychoses in the middle period, and senility and arteriosclerotic psychoses in the later period—is an important consideration in planning a mental hygiene program. In the third chapter mental disease in urban and rural populations is compared. In Chapter IV, marital status in relation to mental disease is discussed. Except for general paresis, the incidence of mental disease is found to be higher in the single than in any other group, but it is pointed out that the marital status probably represents selection on the basis of mental characteristics. In Chapter VII, "Race and mental disease," particularly interesting findings occur. It is found that the Irish show by far the highest rate of first admissions—due primarily to

mental diseases associated with old age and with alcoholic addiction. The Scandinavians rank second, ranking high in general paresis and alcoholic psychoses. Germans, Italians, and English follow in the order named. It is stressed that cultural factors must be considered in any interpretation of these findings, and that racial factors alone may be misleading. In Chapter X, "Mental disease among Negroes," it is shown that the ratio of first admissions in Negroes as compared with whites is 2 to 1. Dementia praecox is the leading psychosis, with general paresis ranking second, manic-depressive psychosis third, alcoholic psychoses fourth. In Chapter XI, economic factors in relation to mental disease are considered. In the twelfth chapter it is found that illiterates have higher rates of first admissions than literates. It is not felt, however, that illiteracy and mental disease are causally related, but that both arise from the same social conditions. In Chapter XIII, it is found that mortality rates at corresponding ages are from 3 to 6 times as great among patients with mental disease as among the general population. This heavy mortality results in a reduction of approximately 18 years and 14 years in the life span of the male and female patients, respectively. In the fourteenth chapter, the efficacy of insulin shock therapy in dementia praecox is evaluated. It is reported that, following termination of treatment, 12.9 percent of the patients were reported recovered and 65.4 percent improved. One year after termination of treatment, all of the recovered patients were still recovered and 49.0 percent were still improved. In untreated cases the recovery rate was only 4 percent and the improved rate 11 percent. Paranoid and catatonic types showed better results than hebephrenics, and short duration of illness before treatment was a favorable factor.

The data on which the conclusions are based in each chapter are included in tabular form and the results of analysis shown in simple, lucid graphs. The discussion is presented briefly and concisely. There is a bibliography and an index.

LE SYNDROME DE DÉSINTÉGRATION PHONÉTIQUE DANS L'APHASIE.

By *Th. Alajouanine, André Ombredane, and Marguerite Durand. Masson et Cie, Paris.*
80 cents. 9 x 6; 138; 1939 (paper).

Four cases in which aphasia accompanied paralysis of the right side were each observed and treated by the authors over a number of years. Although the results of the usual neurologic examinations, psychologic, and reflex tests are presented for each of these patients, it is with the phonetic defects that the authors are particularly concerned. Although the mutations in the pronunciation of words differed with the patients some of the fairly consistent tendencies included the use of a lip stop consonant at the beginning of words, the substitution of buccal vowels for nasal, such as *da* for *dans*; suppression of *r*, especially when it should be vibrant, or its substitution by a liquid, e.g. Lobé for Robert [the illustrative words are, of course, French throughout the book]; the substitution of hard consonants for soft, such as *pépi* for *bibi*; etc. One of the patients made few mistakes in spelling, word order, or grammar when putting into writing sentences which were spoken to her, or in giving in writing resums of anecdotes and stories in pictures. The other three, in similar tests, elided syllables, transposed letters, and made other errors in spelling and grammar. None of these written products, however, resembled in their errors the phonetic mutations of the same material when given orally. In general the oral "phonetic disintegration" appeared to manifest itself in a reversion to a "primitive" mode of articulation resembling the first efforts of a child learning to talk.

A brief theoretical discussion as to the cause of this malady and suggestions for reeducation in speaking and writing, with which the authors have had some success, are included. The illustrations consist of graphic representations of lip and laryngeal movements in the pronunciation of certain words as made by normal persons and the patients, as registered on Rousset's cylinder.

THE VARIETIES OF HUMAN PHYSIQUE: An Introduction to Constitutional Psychology.

By W. H. Sheldon with the collaboration of S. S. Stevens and W. B. Tucker. Harper and Bros., New York and London. \$4.50. 9½ x 6½; xii + 347 + 45 plates; 1940.

The major portion of this book is devoted to outlining a method of classifying and grading body build. The approach described is two-fold. First, by visual inspection of photographs the amount of the endomorphic, mesomorphic, and ectomorphic component, respectively, of the body and of its divisions is estimated on a seven-point scale. This estimate for the body as a whole is supplemented by the value derived from the use of the index: stature divided by cube root of weight, and for other body segments by the values of indices calculated from measurements taken on the photographs. After averaging in a number of ways the estimate and the computed indices, a single index such as, for example, 425 is finally obtained. This index supposedly reveals that in the particular subject the endomorphic component equals 4, the mesomorphic 2, and the endomorphic 5. In the usual terms of constitutional somatology this subject would be described as an asthenic—intermediate, or a flaccid asthenic. According to the scheme of the authors there are 343 possible somatypes, ranging from 111 (!) to 777 (!) but only 76 have been observed in 4000 male college students. The authors deserve praise for the ingenuity displayed although their index does not differ substantially from others based on combined mensurational and impressionistic techniques. On practical and rational grounds they have all proven unsatisfactory. A successful solution of the problem of somatotyping is essential to the further progress of constitutional somatology but until the problem is more clearly understood than so far has been the case, the classification of physical types must still be determined by some anthropometric indices or on the basis of the temperament types described centuries ago and to which the authors have also had recourse.

GETTING MORE OUT OF LIFE.

By Joseph Jastrow. Emerson Books, New York. \$2.00. 8 x 5½; viii + 312; 1940. Although the reference of certain British physicians of the old, or thick-skulled school to a nervous breakdown as an "American luxury" is a slight exaggeration of the facts, there is sufficient mental instability among all classes of society to warrant an increase in the number of psychiatric clinics, as well as an increase in the number of psychology books for the masses by such level-headed psychologists as Jastrow. Until the layman has become thoroughly acquainted with the capabilities and limitations placed upon him by his heredity and his environment, there will remain many psychological mis-fits in our various branches of society. After a person has gained some idea of his own psychological assets and liabilities, the next step in his training to get more out of life is the dispelling of fears, signs, beliefs, and superstitions. The third step to the threshold of happy living is a recognition of the interdependence of mind and body. Jastrow believes that

"In the near future medicine will recognize *psychosomatics* as the study of mental action on bodily states in health and disease" and that "There are all sorts of difficulties which only the knife can remove; but in every case the total patient must be considered and a goodly part of him is his mental attitude in disease." He also agrees with a wise British doctor that "When a man is so ill that he thinks he is ill when he is not ill at all, then he is very ill indeed."

The book is written in a stimulating and quite readable manner, and is replete with cases from the author's files. There is a table of contents, but no index.

**MATHEMATICO-DEDUCTIVE THEORY OF ROTE LEARNING. A Study in Scientific Methodology. Published for the Institute of Human Relations.**

By Clark L. Hull, Carl I. Hovland, Robert T. Ross, Marshall Hall, Donald T. Perkins and Frederic B. Fitch. Yale University Press, New Haven; Oxford University Press, London. \$3.50. 9½ x 6½; xii + 329; 1940. The theory of rote learning set forth in

these pages represents the coordinated effort of psychologists and mathematicians. "While it is believed by the authors that the present monograph contributes to an understanding of the learning processes, it is judged that its chief value consists in the large-scale pioneering demonstration of the logico-empirical methodology in the field of behavior." Scientific development is constituted of the relationship between observations and ideas. The experimental procedure used in obtaining the observed facts of rote learning is described, definitions are given, and a set of postulates is developed. The theoretical system is made up of numerous theorems derived from these definitions and postulates, and couched in the symbolism of mathematics and logic. Theorems are then checked against the observed data and are found in some cases to be inadequate, although on the whole they have been experimentally verified. The authors express the belief that by utilizing the methodology presented in this volume the social sciences may eventually attain the predictive power which characterizes the physical sciences. However, until such specialists as were engaged in the present work further demonstrate the general applicability of the system, it is doubtful if it will command the attention of but a few individuals.



NEGRO CRIME. *Comparative Psychology Monographs. Volume 16, Number 2. Serial Number 81.*

By Jess Spirer. *The Johns Hopkins Press, Baltimore.* \$1.25. 10 x 6½; 64; 1940 (paper).

This study of Negro crime is based on the commitment records of the Western State Penitentiary, Pittsburgh, Pennsylvania, between 1906 and 1935. It is found that when proportional incidence of population is taken into consideration, Negroes have been committed to the penitentiary 9.69 times as frequently as native whites. The highest proportional commitment is found for crimes of violence (murder and assault) for which Negroes were com-

mitted 29.06 times as frequently as native whites. Possible explanations of this proportionally large number of commitments among Negroes are discussed and the conclusion reached that it cannot be entirely accounted for by (a) the presence of proportionately more males in the Negro population, (b) the presence of proportionately more males in the crime committing ages in the Negro population, (c) the presence of Negroes who are not native-born Pennsylvanians, or (d) the concentration of Negro populations in industrial areas. It is likewise concluded that there is insufficient evidence to ascribe to the Negro a biological inferiority to account for his so-called "criminality." There is a bibliography of 110 titles.



A STUDY OF EXPERIMENTALLY INDUCED COMPETITIVE BEHAVIOR IN THE WHITE RAT. *Comparative Psychology Monographs. Volume 15, Number 6. Serial No. 78.*

By Charles N. Winslow. *The Johns Hopkins Press, Baltimore.* 75 cents. 10 x 6½; 35, 1940 (paper).

The writer proposed to attempt to answer several questions as to the effect which competition has on the rat. To this end three experiments were set up in which first singly and then in pairs the animals (1) ran over a straight course to a visible food reward; (2) ran mazes to the reward; and (3) pulled the reward from above by means of a pulley. The writer concludes that "Rats respond competitively to one another when they are rivals for a single piece of food" and that the animals may respond in one of two ways; either by an increased effort or by inhibition as a result of frustration at losing. Inasmuch as two rats would often fight over the food if they both arrived at the same time there was obvious competition. But from the writer's statements as to the initial behavior of the animals upon release, coupled with the lack of statistical significance of the differences in competitive and non-competitive times, it would appear that by and large the rats just did not know what it was all about.

THE FIRST FIVE YEARS OF LIFE. *A Guide to the Study of the Preschool Child. From the Yale Clinic of Child Development.*

Part One by Arnold Gesell; Part Two by Henry M. Halverson, Helen Thompson, Frances L. Ilg, Burton M. Castner and Louise B. Ames; Part Three by Arnold Gesell and Catherine S. Amatruda. Harper and Bros., New York and London. \$3.50.

9½ x 6½; xiii + 394 + 21 plates; 1940.

Gesell and his associates summarize their views and conclusions on the behavioristic development of children from birth to six years of age. In the first part of the book a general picture is given of the typical pattern of motor responses and adaption, language and person-social behavior traits at different stages in infancy and early childhood. Included are a series of beautiful photographic illustrations of the type found in Gesell's principal publications. In the second part of the book a detailed discussion is presented of the development of each of the above characteristics. The third part contains an outline of the method and technique of examination. It is needless to say that this is probably the most authoritative and comprehensive work on a subject in which the work of the author and his group have been greatly responsible for such progress as has been made.



SELECTED WRITINGS OF SIR CHARLES SHERRINGTON. *A Testimonial Presented by the Neurologists Forming the Guarantors of the Journal Brain.*

Compiled and Edited by D. Denny-Brown. Paul B. Hoeber, Medical Book Department of Harper and Bros., New York. \$7.50.

9½ x 7½; xiv + 532; 1940.

This compilation at once pays tribute to the genius of Sir Charles Sherrington and serves as an excellent reference book for neurologists, physiologists, and psychologists. No pretense is made to cover the entire range of contributions, but the selection offers those papers which are of greatest interest to workers in these fields. An effort has been made to give the volume chronological continuity as well as an orderly arrangement of the subjects treat-

ed. The reprints and extracts include discussion of motor and sensory innervation, spinal and bulbar reflex activity, postural reflexes, reciprocal innervation, the motor cortex, and the nature of reflex excitation and inhibition. The entire volume represents a masterful piece of work in editing and compiling this vast body of material. Following the text is a complete bibliography of Sherrington's papers and a thorough index.



DIE TIERISCHEN INSTINKTE UND IHR UMBAU DURCH ERFAHRUNG. *Eine Einführung in die Allgemeine Tierpsychologie.*

By J. A. Bierens de Haan. E. J. Brill, Leiden. 8 guilders (paper); 10 guilders (cloth). 9½ x 6½; xi + 478; 1940.

The author has rendered a service to psychologists in bringing under one cover the work of numerous laboratories in an effort to synthesize an understanding of the processes of instincts, their changes through experience and learning, and their place in the total personality of animals. After a general discussion and an ordering of the more important instincts the author attempts to find out whether the instincts are endowed with "plasticity and elasticity." From the published literature and his own researches he concludes that they are, and may be manifested in variations, adaptations, and regulatory processes. He further affirms that some can also be influenced by training and imitation.

The bibliography covers 35 pages, and an index of authors and one of animals has been provided.



STUDIES OF ABNORMAL BEHAVIOR IN THE RAT. II. A Comparison of Some Convulsion-Producing Situations. *Comparative Psychology Monographs. Volume 16, No. 1.*

By Norman R. F. Maier and Nathan M. Glaser. The Johns Hopkins Press, Baltimore. 75 cents. 10 x 6½; 30; 1940 (paper).

There have been a number of experiments which demonstrate the occurrence of

paroxysms in animals as a result of certain types of auditory stimulation. The present study was designed to determine to what extent the behavior abnormalities are related, and to offer possible explanations. The stimuli (jingling keys, hissing air, bell, buzzers, and whistle) were given to the rats under varying degrees of confinement and conflict-producing conditions. Several interesting findings are reported, chief among which is the increase in frequency of convulsions when the rats are involved in a conflict situation to which they have no adequate response. The study is well planned and clearly presented, but is open to criticism in respect to the small number of animals in the experiments.



COMPARATIVE PSYCHOLOGY: A Comprehensive Treatise. Volumes II, Plants and Invertebrates.

By Carl J. Warden, Thomas N. Jenkins and Lucien H. Warner. The Ronald Press, New York. \$6.00. 8½ x 5½; xiii + 1070; 1940.

This book represents a compendium of the literature on plant and invertebrate comparative psychology and behavior, and contains a staggering list of references which covers 213 pages. The material in each chapter is organized under two broad headings: receptive capacities and reactive capacities of the ground under consideration. The material has been well digested and is concisely summarized. An invaluable source book for the biologist who is interested in more than the morphological side of his subject. There is a subject and author index.



DE OMNIBUS REBUS ET QUIBUSDEM ALIIS

HISTORY AND SCIENCE: A Study of the Relation of Historical and Theoretical Knowledge.

By Hugh Miller. University of California Press, Berkeley. \$2.00. 8½ x 5½; x + 201; 1939.

This is a philosophical discussion of two fields of intellectual exploration, as re-

stricted by the author's own definitions. Science he limits to the study of things that occupy space, and History he expands to the study of Processes that occupy time. It was Darwin's epoch making book that caused the scientists of subsequent generations to become time-conscious; previous to Darwin all science was purely descriptive and entirely devoid of any tendency to draw inferences by which the future might be forecast.

For this reason, according to the author, Darwin and his satellites are not so much historically-minded scientists as they are scientifically-minded historians. This seems a mere verbal quibble at first, especially when we recall that modern relativity physics bids fair to accomplish the synthesis of time and space, if indeed it has not already done so. Also the author believes that the philosophy of the historian is more likely to be empiric than that of the scientist. This is surprising for one would naturally think that a philosophy limited to the contemplation of things would be empiric rather than one devoted to the contemplation of processes which can be apprehended only by observing things and drawing inferences from the changes wrought in them by time. But this supposition the author most emphatically denies. It is difficult to follow his logic, but the reader who endeavors to follow honestly the author's thought is likely to be converted by the essentially sane and healthy conclusions to which the author leads him before he gets half-way through the book.

Perhaps most readers will feel that the chapter dealing with the relation of history and religion is the most vital in the entire work, especially in view of the strange tendency today among representatives of organized religion to derive aid and comfort from Heisenberg's uncertainty principle. This tendency seems more pronounced among those whose understanding of Heisenberg is least, and its implication is that religion can flourish better in a chaotic than in an orderly universe.

Miller says nothing about Heisenberg but his discussion of the historical aspect of religious development leaves no doubt as to where he stands. Primitive peoples

have developed religion only insofar as they have been able to perceive unifying principles in the universe. They pray for favor to anthropomorphic personifications of these principles. There would be no point to prayer in a universe so chaotic that all happenings were fortuitous. The theory of evolution, by making the scientific mind time-conscious and also by accentuating the unity of the universe, has served to check rather than to accelerate the *Götterdämmerung* of Christianity; notwithstanding the statements of certain shallow-minded ecclesiasts who attribute to the theory the materialism of the nineteenth century.

The closing chapters dealing with democracy and progress are also vitally significant and it is to be hoped that this work will receive the attention that it merits, for it is a really valuable contribution to modern scientific and philosophic thought. Unfortunately it has no index.



THE WANDERING LAKE.

By *Sven Hedin*. Translated from the Swedish by F. H. Lyon. E. P. Dutton and Co., New York. \$3.75. 9 $\frac{3}{4}$ x 6 $\frac{1}{4}$; x + 291 + 31 plates; 1940.

Sven Hedin's name has become so well known through earlier books of his that no special introduction is necessary here, but the title of the present work is misleading and requires some explanation.

The lake of Lop-Nor was fed by the Konche-daria, and has no outlet but by evaporation. Some distance above the lake the river is divided as if by a delta, but the two arms so formed never unite again. The other branch is the Kum-daria, which at the time of the author's first visit to this part of Central Asia in the last century was quite dry. It terminated in a sink. Any one accustomed to the vagaries of rivers in desert countries, like our own Colorado as de Niza and Kina saw it, before its spirit was broken by the harness of dykes and levees that now restrain it, can readily understand how the flow of such a stream might alternate between the two arms of the delta, and if each arm led to its own

sink there would be two lakes, which would alternate in receiving the flow of the water. The lake of Lop-nor was two independent lakes that existed not simultaneously but alternately.

Sven Hedin's story is of interest not because it is the report of a strange natural phenomenon, but because on visiting the area in 1900 he prophesied that in the next generation the stream would shift beds again for the first time since the year 330 A.D. On his return in 1934 he found his prophecy fulfilled. Since the lake occupies a position of extreme inaccessibility in the plateau of Central Asia, seldom visited by white men, the story is of great interest and importance, and the numerous illustrations, by the author, add much to it. It is well indexed and has several maps.



SCIENCE FRONT 1939.

By F. Sherwood Taylor. Cassell and Co., London, Toronto, Melbourne and Sydney; The Macmillan Co., New York. 7s. 6d. net in England; \$2.50 in America. 7 $\frac{3}{4}$ x 5; 301 + 8 plates; 1939.

The *Science Front* of 1939 was so broad that it was nearly impossible for one reporter to cover it entirely, but this is an admirable attempt. The clarity and precision with which are discussed such technical topics as chemotherapy, sex and the steroids, television, the atom, the treatment of cancer, schizophrenia, the aurora borealis, plant growth substances, and the universe, is commendable. For anyone beyond the age of 16, whether his interests lie in biology, chemistry, physics, medicine, astronomy, or radio, this book will prove to be as fascinating as it is informative.

In discussing such vast topics—about any one of which countless volumes can be, and have been, written—it is impossible to develop the entire field. The discussions are restricted to the most recent discoveries, developments, theories, aspirations, and lines of research in the various subjects. When the scientific advancements of the past decade are compared with those of the previous five decades,

the astoundingly accelerating pace of science is fully realized.

The textual material is well supplied with formulae, charts, graphs, drawings, and photographs, and is provided with a complete index.



THE CHICAGO COLLEGE PLAN.

By Chauncey S. Boucher. Revised and Enlarged after Ten Years' Operation of the Plan by A. J. Brumbaugh. University of Chicago Press, Chicago. \$3.00. 8 x 5½; xiii + 413; 1940.

It is about fifteen years since the University of Chicago first decided to compensate for the long neglect of its undergraduate schools by developing a system that would raise these parts of the University to the prominent rank of its graduate divisions. The result of this decision was the formulation of the "Chicago College Plan," now widely known, but first presented to the faculty in May, 1928, in a report of the progress made by the special faculty committee on the undergraduate colleges. The freshmen entering in September, 1931, were the first students to enroll under the new, or divisional, plan. The first edition of the present book was written and published in 1935 by the dean of the College; it might well be considered another report of progress. The 1940 edition, revised by Dean Boucher's successor, discusses the plan ten years after the initial changes that put it into operation. Dean Brumbaugh's edition is a good presentation of an attractive educational program by a man who is familiar with its operation, and as such it should be worth reading by anyone interested in our modern schools.



THE AUTHOR PUBLISHER PRINTER COMPLEX.

By Robert S. Gill. Williams & Wilkins Co., Baltimore. \$1.00. 7½ x 5; iv + 76; 1940.

This handy volume is in no sense a style manual. It gives neither rules for punctuation, nor for grammar, nor does it give "Examples": yet it does contain the essential directions for preparing a manu-

script for the printer. Written by one with many years' experience in the publishing business, it gently, and at times with considerable humor, leads the reader through the different stages that printer and author have more or less in common in the process of getting a manuscript before the public. The beginning author, or editor, heeding the invaluable suggestions herein discussed will find this particular part of his work moving along with astonishing ease.



MAKE YOUR PICTURES SING! *How to Perfect Your Technique.*

By Paul L. Hexter. Camera Craft Publishing Co., San Francisco. \$3.00. 8½ x 6; 188; 1940.

Written in a manner completely understandable to the amateur photographer, this is one of the best of numerous recent volumes on the subject. It presents many practical suggestions for producing fine photographic results. The principles described are well illustrated, but the book lacks an index.



1940 BRITANNICA BOOK OF THE YEAR. *A Record of the March of Events of 1939.*

Prepared under the Editorial Direction of Walter Yust. Encyclopaedia Britannica, Inc., Chicago, London and Toronto. \$10.00. 10½ x 8½; xx + 748; 1940.

A useful record, alphabetically arranged, of events of 1939 in all fields of endeavor and all parts of the world. As in the earlier volumes of these annuals, illustrations, an index, and a calendar of events of the year have been provided.



UNIVERSITY OF COLORADO STUDIES. *Series B. Studies in the Humanities. Vol. 1, No. 2. Containing: Aspects of the Relations between Philosophy and Literature, by Joseph W. Cohen; Chaucer's Text-book of Astronomy; Johannes de Sacrobosco, by Walter B. Veazie; James Thompson in Central City, by Marjorie L. Reyburn; Some Notes on the Plays of T. J. Dibdin, by James Sandoe. University of Colorado, Boulder. \$1.00. 10 x 6½; 104; 1940 (paper).*



THE PRICES OF BIOLOGICAL BOOKS IN 1940

BY MAUD DEWITT PEARL AND RAYMOND PEARL

Department of Biology, School of Hygiene and Public Health, Johns Hopkins University

WHEN the QUARTERLY REVIEW OF BIOLOGY began publication in 1926 the custom was inaugurated of reporting at the end of each volume on the cost of the books that had been reviewed in its columns during the year. The present paper, therefore, is the fifteenth of these reports on the prices of biological books. The prices of foreign books have been converted into dollars on the basis of the exchange at the time the books were received. Table 1 shows the findings for 1940, arranged in the customary manner.

Table 1 shows definitely effects of the impact of World War II upon the scholarly activities of Europe. This accords with the anticipation expressed in last year's report. Already it is clear that the report for 1941 will present a still sadder picture. In 1940 the first evident effect is in the decreased total number of pages of biological books from the belligerent countries reviewed in these columns. The total number of pages reviewed in 1940 is 164,654, a decrease of 14,947 pages or 8.3 percent below 1939. The falling off in material from belligerents was 4,842 pages, or 66.5 percent for Germany; 4,003 pages, or 41.2 percent for France; 3,090 pages, or 18.8 percent for Great Britain; and 1,579 pages, or 10.0 percent for British-American books. These four items together represent a loss of 13,514 pages. Also the U. S. Government publications reviewed in 1940 had

4,194 fewer pages, or 47.0 percent, than those reviewed in 1939 from the same source. To offset these deficits there were increases of only 1,989 pages for U. S. A. books (other than governmental); 452 pages for Other countries; and 320 pages for British Government publications. The changes in prices of books from the belligerent countries will be discussed below.

In the fifteen years of the QUARTERLY REVIEW's history the books reviewed in these columns have aggregated a total of 1,968,919 pages. To American buyers these cost in the aggregate a total of \$20,879.34, leading to an average price per page for the total of 1.060 cents. The weighted average cost of 0.959 cents per page for all the books reviewed in 1940 is 10.4 percent lower than that for all the books reviewed in our columns during the preceding fourteen years 1926-1939 inclusive, taken as a bulk total. It is higher than the corresponding average for 1939 of 0.941 cents per page by 1.9 percent. The 1940 average price per page for all books reviewed is 12.6 percent lower than the corresponding figure for 1926, which was 1.097 cents. But the generally accelerating fall in the prices of biological books that began in 1937 and was commented on in last year's report was somewhat checked in 1940, as will appear later in the more detailed analysis presented in Table 2 below.

In 1939 Germany stayed in her cus-

TABLE 1
Prices of biological books, 1940

ORIGIN	TOTAL PAGES	TOTAL COST	PRICES PER PAGE
			<i>cents</i>
Germany.....	2,547	\$56.63	2.22
British American...	14,178	179.45	1.27
British Government	1,300	16.19	1.25
Great Britain.....	13,380	149.29	1.12
Other countries.....	4,758	51.39	1.08
United States.....	118,057	1,088.95	0.92
France.....	5,706	30.45	0.50
U. S. Government..	4,728	6.90	0.15
Totals and weighted average, 1940...	164,654	1,579.25	0.959
Totals and weighted average, 1926-1939 incl.	1,804,265	19,300.09	1.070

1941 very few, if any, German books for review. Since last June there have been virtually no books coming through to us for review from that source.

Following the custom inaugurated some years ago Table 2 shows the price trends of books published in various countries during the decade from 1931 to 1940 inclusive and the absolute and relative changes in price from 1939 to 1940 and from 1931 to 1940.

The average prices per page of our samples of biological books were *lower* this year than in 1939, from only three sources, namely "Other countries," British Government, and France. The drop was relatively large for "Other

TABLE 2
Comparison of the prices of biological books for the decade from 1931 to 1940

ORIGIN	AVERAGE PRICE PER PAGE										CHANGE + OR - FROM 1939 TO 1940		CHANGE + OR - FROM 1931 TO 1940	
	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	Absolute	Relative	Absolute	Relative
	<i>cents</i>	<i>cents</i>	<i>cents</i>	<i>cents</i>	<i>cents</i>	<i>cents</i>	<i>cents</i>	<i>cents</i>	<i>cents</i>	<i>cents</i>	<i>cents</i>	<i>per cent</i>	<i>cents</i>	<i>per cent</i>
British-American.....	2.27	1.48	1.29	1.45	1.53	1.81	1.44	1.16	1.10	1.27	+0.17	+15.5	-1.00	-44.1
Other countries.....	1.53	1.02	0.85	0.86	1.20	2.26	0.86	2.18	1.48	1.08	-0.40	-27.0	-0.45	-29.4
Great Britain.....	1.19	0.89	0.66	0.96	0.84	0.94	1.27	1.04	1.02	1.12	+0.10	+9.8	-0.07	-5.9
United States.....	1.05	1.00	1.02	0.93	0.90	1.03	0.93	0.96	0.90	0.92	+0.02	+2.2	-0.13	-12.4
Germany.....	1.75	1.60	1.43	1.89	2.04	1.84	1.95	2.32	2.16	2.22	+0.06	+2.8	+0.47	+26.9
British Government....	1.03	1.45	1.39	0.89	0.50	1.62	0.34	0.45	1.30	1.25	-0.05	-3.8	+0.22	+21.4
France.....	0.69	0.60	0.74	1.00	0.86	1.05	0.85	0.72	0.63	0.53	-0.10	-15.9	-0.16	-23.2
U. S. Government.....	0.28	0.36	0.17	0.18	0.11	0.21	0.16	0.17	0.14	0.15	+0.01	+7.1	-0.13	-46.4

tomary position at the head of Table 1, as the source of origin of highest prices for biological books. And, in general, all the sources of origin stood this year in about their usual order, except for the dropping of the "Other countries" item from second to fifth place on the list, and some unimportant internal rearrangement of the three British items.

In 1939 the German biological average book prices per page dropped a little from the previous year's level. But in 1940 the average price increased over 1939, by an insignificantly small amount. By present indications we shall have in

countries" (27 percent) and France (15.9 percent). In the case of all the other sources of origin the prices were *higher* in 1940 than in 1939, by amounts ranging from about 2 percent for books commercially produced in the United States to 15.5 percent for the British-American publications. French books continued and enlarged, both absolutely and relatively, the decline in average price per page noted last year.

Over the ten year period from 1931 to 1940 inclusive the average prices per page of the books here reviewed showed a *decline* from every source of origin except

two, namely Germany and British Government. These declines ranged from 5.9 percent in the case of books commercially published in Great Britain to 46.4 percent in the case of U. S. Government publications. The United States Government still continues to disseminate scientific information at a price to the consumer well below any other source known to us. American biologists, of course, pay their due share of the taxes that make this beneficence possible, in last analysis. But, in all fairness, it is probable that most of them

these 15 years covered by the averages for every dollar spent for biological books commercially published in the United States \$1.65 had to be spent on the average for biological books published in Germany. And similarly, *mutatis mutandis*, for other comparisons.

It is evident, from what has now grown to be a substantial sample, that during the past fifteen years biological books from all over the world taken together have averaged to cost the American biologist very close to a cent a page, taking good, bad, and indifferent

TABLE 3
Average biological book prices over the fifteen year period, 1926-1940 inclusive

ORIGIN	TOTAL PAGES	AVERAGE PRICE PER PAGE	RELATIVE AVERAGE PRICE ON BASE 100 FOR							
			U. S. Govt.	France	Brit. Govt.	U. S. A.	Great Brit.	Other Count.	Brit. Amer.	Ger- many
		<i>cents</i>								
Germany.....	182,904	1.651	794	241	168	165	160	122	112	100
British-American.....	144,701	1.479	711	216	151	148	143	109	100	89
Other countries.....	61,375	1.354	651	197	138	135	131	100	92	82
Great Britain.....	163,396	1.033	497	151	105	103	100	76	70	63
United States.....	1,192,655	1.001	481	146	102	100	97	74	68	61
British Government.....	11,499	0.982	472	143	100	98	95	73	66	59
France.....	148,267	0.686	330	100	70	69	66	51	46	42
U. S. Government.....	64,122	0.208	100	30	21	21	20	15	14	13
Total and weighted average...	1,968,919	1.060	—	—	—	—	—	—	—	—

will feel that the part of their tax dollar that is spent in this way is much more usefully and wisely spent than a lot of the rest of it.

Table 3 sums up the whole fifteen years experience of the QUARTERLY REVIEW. That table has been expanded this year to include a new feature. In the last eight columns of the table the average per page price over 15 years is successively taken as 100 (bold figures) for each source of origin of the books. Then the average prices per page for every other source of origin is expressed in the same column relative to 100. So then it is seen, for example, that over

together. Furthermore it is plain that the sources of origin of these books fall into three fairly sharply defined groups relative to unit prices to the American buyer. In the first or relatively high priced group fall books in the British-American, Germany, and "Other countries" categories of origin. The primary reason why the British-American books fall in this category is because they carry an import duty charge, paid on the sheets manufactured in England but issued here by an American branch house. The next or medium priced group includes the United States, British Government, and

Great Britain (commercial publishers). None of the books in this category carry import duty charges in the prices here tabulated, because in the case of the British books the English prices are used. Actually an American buying these books would have to pay duty. This would then, in fact throw them into the same group as the British-American publications. Finally the third or relatively

low price group includes books published in France and by the U. S. Government.

The reader should bear in mind that these reports are based on small samples of books in general and, for some countries, on small samples of the biological books published. He should therefore be cautious in applying conclusions drawn from this material to the general domain of book prices.



INDEX

- Abderhalden, E. (Ed.), Handbook of Biological Methods, 109
- Aboulenc, J. *et al.*, Treatise of Organic Chemistry, Vol. 9, 502
- Adair, F. L. (Ed.), Maternal Care and Some Complications, 107
- Adams, F. (Transl.), The Genuine Works of Hippocrates, 107
- Adamstone, F. B., and Shumway, W., A Laboratory Manual of Vertebrate Embryology, 248
- Adrenal medulla, 156
- Adrian, G. W., and Brison, F. R., Propagation of Horticultural Plants, 246
- Alajouanine, T., The Syndrome of Phonetic Disintegration in Aphasia, 506
- Aldrich, J. W., and Nutt, D. C., Birds of Eastern Newfoundland, 381
- Alvarez, W. C., An Introduction to Gastro-Enterology, 254
- Amberson, W. R., and Smith, D. C., Outline of Physiology, 107
- Amiel, J., *et al.*, Treatise of Organic Chemistry, Vol. 6, 502
- Ammons, Nelle, A Manual of the Liverworts of West Virginia, 382
- D'Ancona, U., The Struggle for Existence, 366
- Anderson, A. K., Essentials of Physiological Chemistry, 110
- Anderson, J. R., Hydrophthalmia or Congenital Glaucoma, 254
- Animal population, structure of, 47
- Anthropometria, 166
- Ants, 123
- Archbold, R., and Rand, A. L., New Guinea Expedition, 373
- ARK, P. A., and PARRY, WILLIET, Application of High-Frequency Electrostatic Fields in Agriculture, 172-191
- Armstrong, H. G., Principles and Practice of Aviation Medicine, 253
- Arnold, J. G., Jr., and Duggan, T. L., Laboratory Manual of General Biology, 469
- Aschoff, L., *et al.*, One Hundredth Anniversary of Cytology, 101
- ASHLEY-MONTAGU, M. F., Physiology and the Origins of the Menstrual Prohibitions, 211-220
- Atwood, W. H., Introduction to Vertebrate Zoology, 378
- Austin, F. E., Governments and Birth Control, 479
- von Baer, K. E., 3
- Bagshawe, T. W., Two Men in the Antarctic, 373
- Baitsell, G. A., Human Biology, 476
- Baker, F. C., Fieldbook of Illinois Land Snails, 242
- Baker, O. E., *et al.*, Agriculture in Modern Life, 231
- BALAMUTH, W., Regeneration in Protozoa: A Problem of Morphogenesis, 290-337
- Ball, Alice M., Compounding in the English Language, 398
- Bamann, E., and Myrbäck, K., Methods of Enzyme Research, 503
- Banta, A. M., *et al.*, Studies on the Physiology, Genetics and Evolution of Some Cladocera, 364
- Barbour, T., and Carr, A. F., Jr., Antillean Terrapins, 486
- Barkley, F. A., Keys to the Phyla of Organisms, 248
- Barnwell, Mildred G., Faces We See, 91
- Barrett, C., Koonwarra, 227
- Barrows, E. F., Pedigrees and Checkerboards, 365
- Bashford, Sir Henry (Ed.), Doctors in Shirt Sleeves, 477
- Baumgartner, Leona, John Howard: Hospital and Prison Reformer, 88
- Bayley, N., Studies in the Development of Young Children, 386
- Bees, 126
- Beetles, 128
- Behavior, comparative, 406
- cooperation in, 405
- Bénard, H., Problems of General Biology and Experimental Pathology, 390
- Benech, J. É., Love of the Hunt, 486
- Bent, A. C., Life Histories of North American Woodpeckers, 96
- Berkeley-Hill, O., All Too Human, 369
- Bertram, C., Arctic and Antarctic, 85
- Bigger, J. W., Man Against Microbe, 99
- Bigwood, E. J., Guiding Principles for Studies on the Nutrition of Populations, 105
- Bingham, Marjorie T., Orchids of Michigan, 248
- BIOCHEMISTRY (book reviews), 108, 255, 390, 502
- Bio-geography, Antarctic, 456
- BIOMETRY (book reviews), 112, 255, 392, 504
- Birker-Smith, K., and de Laguna, Frederica, The Eyak Indians of the Copper River Delta, Alaska, 238
- Biswas, K., and Calder, C. C., Hand-Book of Common Water and Marsh Plants of India and Burma, 491
- Blarina, 29
- Blumer, H., Critiques of Research in the Social Sciences, 231
- Boardman, E. T., Field Guide to Lower Aquarium Animals, 243
- Boas, F., Race, Language and Culture, 479

- Bodansky, M., and Bodansky, O., *Biochemistry of Disease*, 502
- Body build, and intelligence, 436
and temperament, 437
- Bogert, C. M., *Herpetological Results of the Vernay Angola Expedition*, 486
- Bogomoletz, A. A., *et al.*, (Eds.), *Experimental Medicine*, 108
- Bole, B. P., Jr., *The Quadrat Method of Studying Small Mammal Populations*, 379
- Book lice, 129
- Books, biological, prices of, 513-516
- Boos, W. F., *The Poison Trail*, 109
- Bordet, J., *Treatise on Immunity in Infectious Diseases*, 389
- Boxer, M. C., *Mankind in the Making*, 467
- Borgström, G., *The Transverse Reactions of Plants*, 382
- BOTANY (book reviews), 96, 244, 381, 487
- Botley, C. M., *The Air and Its Mysteries*, 470
- Boucher, C. S., *The Chicago College Plan*, 512
- Boyd, W. C., *Blood Groups*, 497
- Boyer, C. B., *The Concepts of the Calculus*, 112
- Brain, W. R., *Recent Advances in Neurology*, 388
- Bremner, M. D. K., *The Story of Dentistry*, 500
- Briggs, E. A., *Anatomy of the Sheep's Brain*, 249
- Brinton, W. C., *Graphic Presentation*, 256
- Brodshaug, M., *et al.*, *Reproduction among Mammals*, 494
- Bronson, W. S., *The Chisel-Tooth Tribe*, 95
- Brown, W., *War and Peace*, 259
- Bryophytes, 460
- Bucher-Triimpler, O. H., and Hofflin-Karwatzki, C. C., *Biological Reaction*, 385
- Buck, F., and Weld, Carol, *Animals Are Like That!*, 379
- Buck, P. H., *Anthropology and Religion*, 235
- Bugs, 129
- Bulletin of Mathematical Biophysics, 78, 256, 394, 504
- Bünning, E., *The Physiology of Growth and Activity*, 107
- Burbank, L., *Partner of Nature*, 225
- Burlingame, L. L., *Heredity and Social Problems*, 365
- Bushnell, L. D., *et al.*, *Poultry Practice*, 376
- Butterfield, O. M., *Love Problems of Adolescence*, 257
- Buxton, P. A., *The Louse*, 481
- Campbell, D. H., *The Evolution of the Land Plants [Embryophyta]*, 488
- Canella, M. F., *Biological Truths in the Works of Schopenhauer*, 469
- Comparative Anatomy in the Field of Modern Biology, 494
- Canaler, C. W., *Three Generations*, 375
- Carbohydrate metabolism, 390
- Cardio-aortic bodies, 164
- Carman, H. J. (Ed.), *American Husbandry*, 381
- Carnegie Institution of Washington, *Year Book No.* 38, 367
- Carotid body, 161
- Carr, A. F., Jr., *A Contribution to the Herpetology of Florida*, 381
- Casson, S., *The Discovery of Man*, 474
- Casteret, N., *Ten Years under the Earth*, 87
- Castle, W. E., *Mammalian Genetics*, 468
- Caterpillars, 132
- Cattell, J. (Ed.), *Biological Symposia*, 470
- Champion, S. G., *Racial Proverbs*, 234
- Channelers of the soil, 28
- Chen, Ta, *Emigrant Communities in South China*, 480
- Chesney, A. M., *The Flowering of an Idea*, 252
- Cheymol, J., *Antianemic Medication and Experimental Anemias*, 500
- Childe, V. G., *Man Makes Himself*, 92
- Christiaens, L., *Studies on the Inheritance of Blood Groups*, 106
- Chromaffin tissue and paraganglia, 156
- Chugerman, S., *Lester F. Ward, the American Aristotle*, 82
- Cicadas, 130
- Ciferri, R., and Giglioli, G. R., *Grain Cereals of Italian Africa*, 245
- Ciliata, 298
- Ciocco, A., *Sex Differences in Morbidity and Mortality*, 59-73, 192-210
- Clark, A. H., *Crinoidea*, 377
- Clark, G., *Archaeology and Society*, 232
- Clark, H. W., *Genesis and Science*, 363
- Clark, Le M., *The Vaginal Diaphragm*, 111
- Clarke, Frances E. (Compl.), *Wild Animals*, 139
- Clarke, J., *Picture of Health*, 386
- Clarkson, Rosetta E., *Magic Gardens*, 245
- Clayton, H. R., and Mitchell, G. S., *Black Workers and the New Unions*, 87
- Clements, F. E., and Shelford, V. E., *Bio-Ecology*, 77
- Cobb, W. M., *The First Negro Medical Society*, 119
- Cocktygeal body, 161
- Cockroaches, experiments in hearing, 137
- Coe, U. C., *Frontier Doctor*, 371
- Coelome, 4
- Colby, M., *A Guide to Alaska*, 89
- Cole, H. A., *Further Experiments in the Breeding of Oysters (*Ostrea edulis*) in Tanks*, 93
- Committee of Dutch Scientists, (Eds.), *The Collected Letters of Antoni van Leeuwenhoek*, Pt. I, 227
- Constitution, nature of, 269
- race factor in, 280
- Constitutional investigations, 268
- methodology of, 411
- make-up, permanence of, 283

- Cooper, K. W., The Genital Anatomy and Mating Behavior of *Boreus brumalis* Fitch (Mecoptera), 485
- Corner, G. W., Attaining Womanhood, 258
- Cottam, C., Food Habits of North American Diving Ducks, 93
- Council on Foods of the American Medical Association, Accepted Foods, 495
- Crickets, 135
- Cross immunity, 346
- Crow, C., The Chinese Are Like That, 234
- Cummins, S. L., Primitive Tuberculosis, 104
- Curry, R., The Mechanism of the Human Voice, 492
- Curtis, W. C., and Guthrie, Mary J., Laboratory Directions in General Zoology, 96
- Cushing, H., The Medical Career and Other Papers, 387
- Cushman, J. A., Foraminifera, 482
- Cutright, P. R., The Great Naturalists Explore South America, 228
- Cyriax, R. J., Sir John Franklin's Last Arctic Expedition, 372
- Dale, E. E., and Litton, G., Cherokee Cavaliers, 371
- Daniel, R. J., *et al.*, (Eds.), Proceedings and Transactions of the Liverpool Biological Society, Vol. LII, 377
- Darling, F. F., A Naturalist on Rona, 228
- The Seasons and the Farmer, 367
- Darrah, W. C., Textbook of Paleobotany, 363
- Definition of constitution, 287
- De Kruif, P., Health Is Wealth, 497
- Denny-Brown, D. (Ed.), Selected Writings of Sir Charles Sherrington, 509
- DE OMNIBUS REBUS ET QUIBUSDAM ALIIS (book reviews), 119, 260, 396, 510
- Deraniyagala, P. E. P., The Tetrapod Reptiles of Ceylon, 380
- Devoc, A., Down to Earth, 469
- De Vries, L., *et al.*, German-English Science Dictionary, 120
- Dodds, E. C. (Ed.), The Journal of Endocrinology, 254
- Dörge, K., Probability Theory for the Non-Mathematical, 114
- Downie, R. A. (Ed.), The Native Races of America, 471
- The Native Races of Asia and Europe, 471
- The Native Races of Australasia, 85
- Drummond, J. C., and Wilbraham, Anne, The Englishman's Food, 494
- Du Bois, W. E. B., Black Folk, Then and Now, 230
- Duncan, C. D., and Pickwell, G., The World of Insects, 94
- Eales, N. B., The Littoral Fauna of Great-Britain, 95
- Earthworms, effect on soil structure and soil fertility, 43
- Eddington, A., *Sir*, The Philosophy of Physical Science, 396
- Eddy, S., *et al.*, Guide to the Study of the Anatomy of the Shark, the Necturus, and the Cat, 249
- Edwards, F. W., *et al.*, British Blood-Sucking Flies, 380
- Ego-drives, 403
- Ekvall, R. B., Cultural Relations on the Kansu-Tibetan Border, 80
- Ellis, H., My Life, 237
- Elmer, M. C., Social Research, 234
- Elsdon-Dew, R., Blood Groups in Africa, 364
- Elwin, V., The Baiga, 370
- Embree, E. R., Indians of the Americas, 233
- Emmart, Emily W., The Badinus Manuscript, 487
- Ets, Maria H., The Story of a Baby, 101
- Evans, H. M., Brain and Body of Fish, 485
- Eve, A. S., The Life and Letters of the Rt. Hon. Lord Rutherford, O. M., 476
- EVOLUTION (book reviews), 74, 224, 362, 466
- Fairchild, H. P., People: The Quantity and Quality of Population, 238
- Fauna of the soil, 29
- Faust, E. C., Human Helminthology, 254
- Findley, P., Priests of Lucina, 82
- Fisher, Vardis, Children of God, 83
- Flies, 129
- Fohrman, M. H., and Graves, R. R., Experiments in Breeding Holstein-Friesian Cattle for Milk- and Butterfat-producing Ability, and an Analysis of the Foundation Cows and of the First Outbred Generation, 76
- Forbush, E. H., and May, J. B., Natural History of the Birds of Eastern and Central North America, 484
- Ford, W. W., Bacteriology, 382
- Forsyth, D., How Life Began, 75
- Fox, I., Fleas of Eastern United States, 380
- Foxe, A. N., The Life and Death Instincts, 260
- Françon, J., The Mind of the Bees, 260
- Franklin Institute, Reports of the Biochemical Research Foundation of the Franklin Institute, Vol. 5, 391
- Fred, E. B., *et al.*, Supplement to Root Nodule Bacteria and Leguminous Plants, 247
- Frederick, J. G., Long Island Seafood Cook Book, 119
- Freeman, H., Mathematics for Actuarial Students, 114
- Freud, S., Moses and Monotheism, 115
- Falconis, H., Congenital Fragility of the Bone, 103

- GALT, WILLIAM, The Principle of Cooperation in Behavior, 401-410
- Galtssoff, P. S., and Loosanoff, V. L., Natural History and Method of Controlling the Starfish (*Asterias forbesi*, Desor), 379
- Gamble, J. A., *et al.*, Composition and Properties of Goat's Milk as Compared with Cow's Milk, 109
- Garoglio, P. G., and Ciferri, R., Experiments in the Production of Oils in Microbiology, 383
- Garrison, K. C., The Psychology of Exceptional Children, 395
- Gastro-intestinal disease, 432
- Geiger, J. C., *et al.*, The Health of the Chinese in an American City, 499
- Geitler, L., Abbreviated Methods in Fixation and Staining, 492
- Gellhorn, E., and Lambert, E. H., The Vasomotor System in Anoxia and Asphyxia, 250
- GENERAL BIOLOGY (book reviews), 77, 226, 365, 468
- GENETICS (book reviews), 76, 225, 363, 468
- Gericke, W. F., The Complete Guide to Soilless Gardening, 488
- Germ-layer concept, 2
- Gershenfeld, L., Biological Products, 391
- Gesell, A., *et al.*, The First Five Years of Life, 509
- Gill, R. C., White Water and Black Magic, 474
- Gill, R. S., The Author Publisher Printer Complex, 512
- Gillespie, S., Celluloid Safari, 238
- Gladstone, R. J., and Wakeley, C. P. G., The Pincal Organ, 493
- Glick, P. A., The Distribution of Insects, Spiders, and Mites in the Air, 94
- Gloyd, H. K., The Rattlesnakes, Genera *Sistrurus* and *Crotalus*, 482
- Goldschmidt, R., The Material Basis of Evolution, 467
- Goldstein, K., The Organism, 77
- Goldzieher, M. A., The Endocrine Glands, 254
- Goodnight, C. J., The Branchiobdellidae (Oligochaeta) of North American Crayfish, 485
- Gordon, K., The Amphibia and Reptilia of Oregon, 380
- Goudet, H. J., *et al.*, Organic Chemistry, Vol. 10, 110
- Goulden, C. H., Methods of Statistical Analysis, 114
- Gover, Mary, Cancer Mortality in the United States, 389
- Grabbe, P., We Call It Human Nature, 395
- Graham, H., The Story of Surgery, 87
- Graham, S. A., Principles of Forest Entomology, 93
- Graubard, M., Man the Slave and Master, 84
- Green, Charlotte H., Trees of the South, 99
- Greenbie, S., Furs to Furrows, 372
- Gregory, T., Eyes in the Night, 379
- Grether, W. F., Color Vision and Color Blindness in Monkeys, 117
- Groves, E. R., and Groves, Gladys H., Sex in Marriage, 504
- Growth, A journal for studies of development and disease, 492
- Guyon, R., Sexual Freedom, 110
- de Haan, J. A. Bierens, Animal Instincts and Their Changes Through Learning, 509
- Haeckel, E. H., 6
- von Hagen, V. W., Ecuador the Unknown, 370
- Haig-Thomas, D., Tracks in the Snow, 90
- Haldane, J. B. S., Adventures of a Biologist, 480
- Science and Everyday Life, 398
- Hall, S. W., III, Tangier Island, 132
- Hamilton, W. J., Jr., American Mammals, 240
- Hansen, M. L., The Atlantic Migration, 1607-1860, 479
- Hanström, B., Hormones in Invertebrates, 250
- Harland, S. C., The Genetics of Cotton, 76
- Harvey, E. N., Living Light, 496
- Hassall, A., Index-Catalogue of Medical and Veterinary Zoology, Pt. 3, C to CZYGAN, 96
- Haupt, A. W., Fundamentals of Biology, 470
- Laboratory Directions for General Biology, 469
- Heard, G., Pain, Sex and Time, 74
- Hearing in insects, 121
- Heart disease, 430
- Hedin, S., The Wandering Lake, 511
- Heffron, R., Pneumonia, With Special Reference to Pneumococcus Lobar Pneumonia, 106
- Heidel, W. A., The Frame of the Ancient Greek Maps, 399
- Height-weight relationships, 414
- Heim, R., Reproduction in Plants, 382
- Heiss, E. D., *et al.*, Modern Methods and Materials for Teaching Science, 399
- Henderson, I. F., and Henderson, W. D., A Dictionary of Scientific Terms, 78
- Henney, K., and Dudley, B. (Eds.), Handbook of Photography, 262
- Henrici, A. T., The Biology of Bacteria, 99
- Herbst, C., 22
- Hertwig, O., 12
- Hertwig, R., 13
- Hexter, P. L., Make Your Pictures Sing, 512
- Hickman, C. P., Functional Human Anatomy, 384
- High-frequency fields, 172
- treatment, economics of, 182
- Himes, N., Your Marriage, 503
- Hines, D., Adventures in Good Eating, 481
- Hinton, C. L., Fruit Pectins, 391
- Hirsch, G. C., Form and Content of the Golgi Bodies, 100

- Hirschfeld, M., *Sexual Pathology*, 392
 His, W., 15
 History of thought on constitution, 265
 Hogben, L., *Dangerous Thoughts*, 394
 Holand, H., *Westward from Vinland*, 472
 HOLLINERMAN, W. H., *Chromaffin Tissue and Paraganglia*, 156-171
 Hou, H. C., *et al.*, *Nutritional Studies in Shanghai*, 388
 Huber, M., *Data on Population Obtained from the Census. Migration*, 475
 Marriages, Births, Fertility, 475
 Huddleson, I. F., *Brucellosis in Man and Animals*, 105
 Hull, C. L., *et al.*, *Mathematico-Deductive Theory of Rote Learning*, 507
 HUMAN BIOLOGY (book reviews), 78, 230, 368, 471
 Human constitution, 265, 411
 Huxley, Elspeth, *Red Strangers*, 86
 Huxley, J., *The Living Thoughts of Darwin*, 75
 Huxley, J. (Ed.), *The New Systematics*, 466
 Huxley, T. H., 5
 Hyman, Libbie H., *The Invertebrates*, 221
- Immunity, plant virus, 339
 Index, Botanical, to the Third Edition of Bibliography of References to the Literature on the Minor Elements and Their Relation to Plant and Animal Nutrition, 501
 Inheritance of constitutional factors, 273
 morphological characters, 273
 physiological characters, 274
 psychological characters, 276
 Innis, H. A., *The Cod Fisheries*, 484
 Insects, use of woodland soils, 39
- Jacobi, K., *Scales and Teeth of Sharks and Rays*, 75
 Jacot, A. P., *The Fauna of the Soil*, 28-58
 Jaeger, E. C., *Desert Wild Flowers*, 489
 Janssen, R. E., *Leaves and Stems from Fossil Forests*, 224
 Jaques, F. P., *The Geese Fly High*, 243
 Jasny, N., *Competition Among Grains*, 489
 Jastrow, J., *Getting More Out of Life*, 507
 Jeanneney, G., and Ringenbach, G., *Treatise on Blood Transfusion*, 501
 Jepsen, Maud, *Biological Drawings*, 368
 Johansen, D. A., *Plant Microtechnique*, 490
 Jones, S. G., *Introduction to Floral Mechanism*, 246
 Jordan, E. L., *Americans*, 78
 Jordan, H. E., *A Textbook of Histology*, 494
 Just, E. E., *Basic Methods for Experiments on Eggs of Marine Animals*, 100
- Kaempffert, W., *Science Today and Tomorrow*, 261
 Kagan, S. R., *Jewish Contributions to Medicine in America*, 389
 Katyids, 134
 Kelso, L. H., *Food Habits of Prairie Dogs*, 243
 Kenly, J. C., *Voices from the Grass*, 380
 Kennedy, F., *et al.*, (Eds.), *The Inter-Relationship of Mind and Body*, 396
 Kerlec, C., *Pictures with a Purpose; How They Are Made*, 262
 King, Blanche B., *Under Your Feet*, 236
 Kingsbury, J. A., *Health in Handcuffs*, 249
 Klauber, L. M., *A Statistical Study of the Rattlesnakes*, 483
 Kleitman, N., *Sleep and Wakefulness*, 115
 von Kölliker, R. A., 11
 Kowalewski, A., 6
 Koya, Y. (Ed.), *Anthropological Studies from the Hygienic Institute of the Medical School, Kanazawa*, 90
 Kroeber, A. L., *Cultural and Natural Areas of Native North America*, 476
 Krogh, A., *Osmotic Regulation in Aquatic Animals*, 106
 Krueger, W. W., *The Fundamentals of Personal Hygiene*, 500
 Kuckuck, H., *Plant Culture*, 99
 Kuczynski, R. R., *The Cameroons and Togoland*, 88
 Kudo, R. R., *Protozoology*, 95
 Kurtz, A. K., and Edgerton, H. A., *Statistical Dictionary of Terms and Symbols*, 114
- Laboratory of Anthropology Bulletin, No. 10, 481
 La Gorce, J. O. (Ed.), *The Book of Fishes*, 378
 Lamb, F. H., *Book of the Broadleaf Trees*, 246
 Lambic, T. A., *A Doctor Without a Country*, 371
 Lanchester, H. P., *The External Anatomy of the Larva of the Pacific Coast Wireworm*, 244
 Lane-Roberts, C., *et al.*, *Sterility and Impaired Fertility*, 392
 Langdon-Brown, W., *Sir, Thus We Are Men*, 118
 Latz, L. J., *The Rhythm of Sterility and Fertility in Women*, 111
 Lawrence, W. J. C., *Practical Plant Breeding*, 225
 Leigh, W. R., *Frontiers of Enchantment*, 85
 Lescure, J., *Sociological Studies of the Democratic and Totalitarian Governments*, 473
 Lewis, A. A., and Turner, C. W., *The Mammogenic Hormones of the Anterior Pituitary*, 385
 Lewis, G. M., and Hopper, Mary E., *An Introduction to Medical Mycology*, 253
 Levison, J. J., *The Home Book of Trees and Shrubs*, 490
 Levy, H., *Modern Science*, 260
 Lichens, Antarctic, 459

- Lincoln, F. C., *The Migration of American Birds*, 378
 Lindhardt, Marie, *The Statistics of Pulmonary Tuberculosis in Denmark 1925-1934*, 251
 Lindsey, A. A., *Recent Advances in Antarctic Bio-Geography*, 456-465
 Lipscomb, A. W. G., *Breeding and Management of Live Stock*, 468
 Lively, C. E., and Tacuber, C., *Rural Migration in the United States*, 238
 Living tissue, effect of menstuous women on, 214
 Locusts, 133
 Long, J. A., *A Pulsating Circulation Apparatus for Tissue Cultures, Embryos, and Small Organs*, 108
 Lotka, A. J., *Analytical Theories of Population Associations*, 393
 Lowe, E. W., *What You Want to Know About Developers*, 399
 Lowie, R. H., *An Introduction to Cultural Anthropology*, 480
 Lubbock, *Sir John*, 124
 Lucas, M. S., *Elements of Human Physiology*, 390
 Luck, J. M., and Hall, V. E. (Eds.), *Annual Review of Physiology*, 498
 and Smith, J. H. C. (Eds.), *Annual Review of Biochemistry*, 108, 502
 Luyet, J., and Gehenio, P. M., *The Physical States of Protoplasm at Low Temperatures*, 103
 Lyon, E., *Diabetes Mellitus and the Jewish Race*, 501
- MacColl, Sylvia H., *A Comparative Study of the Systems of Lewin and Koffka with Special Reference to Memory Phenomena*, 396
 Macmurray, J., *The Boundaries of Science*, 118
 Maier, N. R. F., *Studies of Abnormal Behavior in the Rat*, 118
 and Glaser, N. M., *Studies of Abnormal Behavior in the Rat*, 509
 Main, R. J., *The Care of a Small Rat Colony*, 241
 Malick, C. P., *Labor Policy under Democracy*, 90
 Malzberg, B., *Social and Biological Aspects of Mental Disease*, 505
 Man: a constitutional investigation, 265, 411
 Mangham, S., *Earth's Green Mantle*, 245
 Marais, E. N., *My Friends the Baboons*, 239
 Marett, R. R., *Charity and the Struggle for Existence*, 373
 Marine zone, sub-Antarctic, 457
 Marshall, C., *An Introduction to Human Anatomy*, 102
 Martin, A. C., and Uhler, F. M., *Food of Game Ducks in the United States and Canada*, 92
 Martin, E. V., and Clements, F. E., *Adaptation and Origin in the Plant World*, 383
 Marwick, B. A., *The Swazi*, 472
 Masculinity rate, 64
 Mastigophora, 292
 Matheson, R., *A Laboratory Guide in Entomology*, 241
 Matlin, D. R., *Growing Plants Without Soil*, 100
 McAtee, W. L., *Wild Life of the Atlantic Coast Salt Marshes*, 78
 McCloy, Helen, *The Man in the Moonlight*, 477
 McCoy, E., and McClung, L. S., *The Anaerobic Bacteria and Their Activities in Nature and Disease*, 98
 McLester, J. S., *Nutrition and Diet in Health and Disease*, 253
 McMinn, H. E., *An Illustrated Manual of California Shrubs*, 247
 Mechanism in regeneration, 327
 Medsger, O. P., *Edible Wild Plants*, 246
 Mellanby, E., *See*, *Recent Advances in Medical Science*, 387
 Menkin, V., *Dynamics of Inflammation*, 496
 Menstrual prohibitions, 211
 Mera, H. P., *Population Changes in the Rio Grande Glaze-Paint Area*, 374
 Messel, R., *Refuge in the Andes*, 375
 Metcalf, C. L., and Flint, W. P., *Destructive and Useful Insects*, 240
 Meyer, A. W., *The Rise of Embryology*, 248
 Meyer-Abich, A., *Publications of the German Dominican Institute for Tropical Research*, 229
 Meyer, B. S., and Anderson, D. B., *Plant Physiology*, 98
 Meyers, G. S. (Ed.), *Stanford Ichthyological Bulletin*, 241
 Mielche, H., *Journey to the World's End*, 375
 Miller, H., *History and Science*, 510
 v. Mises, R., *Probability, Statistics and Truth*, 113
 Mittasch, A., *A Short History of Catalysis in Practice and Theory*, 110
 Mixers, of organic residues and mineral soil, 28
 Monroe, D., *et al.*, *Family Income and Expenditures. Pacific Region*, 91
 Morant, G. M., *The Races of Central Europe*, 369
 and Welch, B. L. (Comps.), *A Bibliography of the Statistical and Other Writings of Karl Pearson*, 392
 Morbidity, sex differences in, 192
 Morgan, Ann H., *Field Book of Animals in Winter*, 92
 MORPHOLOGY (book reviews), 100, 248, 384, 492
 Morphology, relation to pathology, 427
 Mortality, prenatal, 63
 sex differences in, 196
 Moths and butterflies, 131
 Motivation, social, 407
 Moulton, F. R., *The Migration and Conservation of Salmon*, 94
 Mühlmann, W., *Methodology of Ethnology*, 88

- Muller, H. J., Bibliography on the Genetics of *Drosophila*, 226
- Murphy, D. P., Congenital Malformations, 363
- Murray, D., The Philosophy of Power, 397
- Murray, H. A., Explorations in Personality, 504
- Myrdal, G., Population, 374
- Nakashian, A., A Man Who Found a Country, 478
- Neave, S. A. (Ed.), Zoological Nomenclature, 92
- Neurosis, racial, 406
- social, 407
- NEW BIOLOGICAL BOOKS, 74-120, 221-263, 362-399, 466-512
- Newton, W. H., Evans' Recent Advances in Physiology, 255
- Nicol, H., Microbes by the Million, 491
- Niehans, P., Senescence and Rejuvenation, 501
- Niemöller, A. F., Feminine Hygiene in Marriage, 111
- Superfluous Hair and Its Removal, 101
- Noble, G. H., and Noble, E. R., A Brief Anatomy of the Turtle, 384
- Non-specificity of the germ-layers, 1
- Norman, E. H., Japan's Emergence as a Modern State, 474
- du Noüy, L., Man and Science, 119
- Ombredanne, L., Hermaphrodites and the Surgeon, 258
- OFFENHEIMER, JANE M., The Non-Specificity of the Germ-Layers, 1-27
- Organ systems, mortality rates according to, 193
- Oscillating electrostatic fields, effect on insects, 174
- on men and animals, 174
- on plants and plant parts, 179
- Osgood, C., Ingalik Material Culture, 480
- Osgood, T. H., Physics in 1939, 399
- Otto, R., *et al.*, (Eds.), The Organism and the Environment, 367
- Pallis, Marietta, The General Aspects of the Vegetation of Europe, 381
- Pander, C., 2
- PARK, THOMAS, Beginning a New Invertebrate Zoology, 221-224
- Parker, J. B., and Clarke, J. J., An Introduction to Animal Biology, 242
- Peacock, H. A., Elementary Microtechnique, 493
- PEARL, MAUD DEW., and PEARL, RAYMOND, The Prices of Biological Books in 1940, 513-516
- Pearl, R., Introduction to Medical Biometry and Statistics, 504
- Peltier, G. L., *et al.*, (Compls.), Laboratory Manual for General Bacteriology, 247
- Personality types, 438
- Peters, J. L., Check-List of Birds of the World, 485
- Peterson, R. T., A Field Guide to the Birds, 483
- Pfeiffer, E., Bio-Dynamic Farming and Gardening, 96
- Pfeiffer, H. H., Experimental Cytology, 383
- Pfeiffer, J., Science in Your Life, 399
- Phillips, A. H., Gardening Without Soil, 488
- Physiological regeneration, 323
- PHYSIOLOGY AND PATHOLOGY (book reviews), 102, 249, 384, 494
- Phytoplankton, Antarctic, 457
- Pickles, W. N., Epidemiology in Country Practice, 498
- Pledge, H. T., Science Since 1500, 262
- Plowden, J. M. C., Once in Sinai, 473
- Pollack, H., Modern Diabetic Care, 499
- Polonovski, M., Annual Survey of Medical Biochemistry, 376
- Pool, R. J., Basic Course in Botany, 491
- Pope, C. H., Turtles of the United States and Canada, 95
- Porter, Annie, the Larval Trematoda Found in Certain South African Mollusca, 377
- Post-natal mortality, 69
- Porter, Edith L., and Adair, F. L., Fetal and Neonatal Death, 388
- Pressey, S. L., *et al.*, Life: A Psychological Survey, 118
- Preston, R. J., Jr., Rocky Mountain Trees, 489
- Price, W. A., Nutrition and Physical Degeneration, 102
- PRICE, W. C., Acquired Immunity from Plant Virus Diseases, 338-361
- Prices of biological books, 513
- Primitive groups, 405
- Proceedings of the Industrial Statistics Conference Held at Mass. Inst. of Tech., Cambridge, 1938, 255
- Protection tests, plant, 351
- PSYCHOLOGY AND BEHAVIOR (book reviews), 115, 258, 394, 504
- Puma, M., Elements in a Mathematical Theory of Epidemics, 504
- Radloff, E. M., and Osborn, T. W. B., Malnutrition in South America, 501
- Raglan, Lord, How Came Civilization?, 368
- Rahn, O., Mathematics in Bacteriology, 394
- Rashevsky, N., Advances and Applications of Mathematical Biology, 393
- (Ed.), The Bulletin of Mathematical Biophysics, 78, 256, 394, 504
- RAU, PHIL, Auditory Perception in Insects, with Special Reference to the Cockroach, 121-155
- Raven-Hart, Major R., Canoe to Mandalay, 478
- Recent Advances in Antarctic Bio-Geography, 456
- Redgrove, H. S., and Foan, G. A., Hair-Dyes and Hair-Dyeing Chemistry and Technique, 390

- Reducers, of litter in the soil, 28
- Reed, C. I., *et al.*, The Vitamins, 251
Vitamin D, 251
- Regeneration in Protozoa: A Problem of Morphogenesis, 290
- Rehder, A., Manual of Cultivated Trees and Shrubs Hardy in North America, 491
- Rery, J., Transition Years, 503
- Reynolds, S. R. M., Physiology of the Uterus with Clinical Correlations, 104
- Ribeiro, L., Criminal Anthropology, 237
(Ed.), Archives of Legal Medicine and Identification, 376
- Rice, J. L., Health for 7,500,000 People, 108
Health for New York City's Millions, 255
- Le Riche, H., Physique and Nutrition, 497
- Rider, P. R., An Introduction to Modern Statistical Methods, 394
- Ries, E., General Histology, 102
- Riesen, A. H., Delayed Reward in Discrimination Learning by Chimpanzees, 396
- Robinson, Mabel L., Runner of the Mountain Tops, 91
- Rosenstock-Huessy, E., Out of Revolution, 236
- Rostand, J. (Ed.), Mating Habits of Animals, 256
- Rouse, I., Prehistory in Haiti, 375
- Ryan, P. E., Migration and Social Welfare, 374
- Rydh, H., Argentine to Andes, 479
- Rylander, G., Personality Changes After Operations on the Frontal Lobes, 116
- Saltzer, C. C., Contributions to the Racial Anthropology of the Near East, 481
- Sandeman, C., A Forgotten River, 229
Sarredine, 293
- Saunders, E. R., Floral Morphology, 491
- Schmidt, W., The Culture Historical Method of Ethnology, 235
- Schuchert, C., and LeVene, Clara M., O. C. Marsh: Pioneer in Paleontology, 475
- Scott, H. H., A History of Tropical Medicine, 384
- Scott, K. Frances, A College Course in Hygiene, 103
- Scott, W. B., Some Memories of a Palaeontologist, 81
- Seaver, G., Scott of the Antarctic, 478
- Sedgwick, W. T., and Tyler, H. W., A Short History of Science, 261
- Seligman, C. G., Races of Africa, 90
- Setty, L. R., Biology and Morphology of Some North American Bittacidae (Order Mecoptera), 485
- Sex (book reviews), 110, 256, 392, 503
- Sex differences, human, 59, 192
in morbidity and mortality, 59
factor in constitution, 282
ratio of stillbirths, 64
- Sheldon, W. H., *et al.*, The Varieties of Human Physique, 507
- Sherborn, C. D., Where is the — Collection?, 468
- Shohl, A. T., Mineral Metabolism, 391
- Shrader, J. H., Food Control, 386
- Siegel, M., Population, Race and Eugenics, 226
- Simpson, G. G., and Roe, Anne, Quantitative Zoology, 112
- Slater, Eleanor, *et al.*, Types, Levels, and Irregularities of Response to a Nursery School Situation of Forty Children, 117
- Smiley, D. F., and Gould, A. G., A College Textbook of Hygiene, 499
- Smith, B. W., The World Under the Sea, 367
- Smith, E. C., Kongo, the Elephant, 96
- Smith, H. W., Studies in the Physiology of the Kidney, 252
- Smith, W. H., and Helwig, F. C., Liquor, the Servant of Man, 253
- Smithsonian Institution, Annual Report of the Regents of, 226
- Snedigar, R., Our Small Native Animals, 93
- Snyder, C., Capitalism the Creator, 368
- Snyder, L. H., The Principles of Heredity, 365
- Sorokin, P. M., and Berger, C. Q., Time-Budgets of Human Behavior, 84
- Speck, F. G., Penobscot Man, 477
- Spemann, H., 17
- Spirer, J., Negro Crime, 508
- Sporozoa, 298
- Spragg, S. D. S., Morphine Addiction in Chimpanzees, 498
- Stallings, W. S., Jr., Dating Prehistoric Ruins by Tree-Rings, 98
- Steere, W. C., Liverworts of Southern Michigan, 382
- Steinach, E., Sex and Life, 392
- Steinberg, S. H., Historical Tables, 471
- Stejneger, L., and Barbour, T., A Check List of North American Amphibians and Reptiles, 96
- Stevens, A. G., The Way of a Lion, 240
- Stevens, Bertha (Ed.), Thoreau: Reporter of the Universe, 233
- Stevens, H. P., and Stevens, W. H., Rubber Latex, 490
- Stewart, T. D., Anthropometric Observations on the Eskimos and Indians of Labrador, 372
- Stiles, P. G., Human Physiology, 107
- Stillbirths, causes of death in, 67
- Stong, P., Horses and Americans, 235
- Strecker, E. A., Beyond the Clinical Frontiers, 258
- Strong, R. M., A Bibliography of Birds, 376
- Stuart, R. R., The Anatomy of the Bull Frog, 249
- Stubbings, H. G., The Marine Deposits of the Arabian Sea, 377
- Sturtevant, A. H., and Beadle, G. W., An Introduction to Genetics, 76
- Sulzberger, Marion B., and Wolf, J., Dermatologic Therapy in General Practice, 499

- Szent-Györgyi, A. V., On Oxidation, Fermentation, Vitamins, Health and Disease, 385
- Tansley, A. G., The British Islands and Their Vegetation, 244
- Taverner, P. A., Canadian Land Birds, 242
- Taxonomic relationships, 300
- Taylor, F. S., *Science Front* 1939, 511
- Termites, 128
- de Terra, H., and Patterson, T. T., Studies on the Ice Age in India and Associated Human Cultures, 362
- Terroine, E. F., Metabolism of Nitrogen, 108
- Thomas, P., Women and Marriage in India, 257
- Thompson, E. T. (Ed.), Race Relations and the Race Problem, 89
- Thompson, H. C., Vegetable Crops, 247
- Thompson, Laura, Fijian Frontier, 477
- Thornton, H., and Freda, How to Achieve Sex Happiness in Marriage, 111
- Thornton, J. E. (Compl.), Science and Social Change, 91
- Timbres, H., and Rebecca, We Didn't Ask Utopia, 79
- Tintner, G., The Variate Difference Method, 393
- Titmuss, R. M., Poverty and Population, 89
- Tobacco-streak disease, 343
- Todd, J. C., and Sanford, A. H., Clinical Diagnosis by Laboratory Methods, 104
- Tompsett, D. H., Sepia, 242
- Tory, H. M. (Ed.), A History of Science in Canada, 399
- Tothill, V., Doctor's Office, 373
- Transactions of the San Diego Society of Natural History, 230
- Tree crickets, 136
- Treloar, A. E., Elements of Statistical Reasoning, 113
- Trimethylamine, 215
- Tschuprow, A. A., Principles of the Mathematical Theory of Correlation, 114
- Tuberculosis, 431
- Tuckers, W. B., and Lema, W. A., Man: A Constitutional Investigation, 265-289, 411-455
- Tulchin, S. H., Intelligence and Crime, 259
- Turner, C. W., The Comparative Anatomy of the Mammary Glands, 493
- Turner, W. I., and Henry, V. M., Growing Plants in Nutrient Solutions, 383
- Tuttle, W. W., and Knowlton, G. C., An Introduction to Experimental Human Physiology, 389
- Types, constitutional, 420
- U. S. Department of Agriculture, Food and Life. Yearbook of Agriculture 1939, 387
- Vagal paraganglia, 168
- Vascular plants, 460
- Vayssiére, P., Principles of Agricultural Zoology, 379
- Verrill, A. H., Wonder Creatures of the Sea, 484
- Vertebrates of Arctic zone, 463
of sub-Arctic zone, 463
- Vertical migrations of animals in the soil, 51
- Verzár, F., The Function of the Adrenal Cortex, 251
- Vestal, P. A., and Schultes, R. E., The Economic Botany of the Kiowa Indians, 97
- Vickery, H. B., *et al.*, Chemical Investigations of the Rhubarb Plant, 247
- Virtanen, A. I., Cattle Fodder and Human Nutrition, 97
- Virus and Rickettsial Diseases, 387
- Virus Relationships, 352
- Waddington, C. H., An Introduction to Modern Genetics, 77
- Walker, K., and Strauss, E. B., Sexual Disorders in the Male, 503
- Wallace, H. A., *et al.*, The Genetic Basis for Democracy, 225
- Wallis, W. D., Religion in Primitive Society, 236
- Warden, C. J., *et al.*, Comparative Psychology, 510
- Warfel, H. E., Biological Survey of the Connecticut Watershed, 470
- Wasps, 127
- Watson, S. J., The Science and Practice of Conservation, 488
- Wechsler, D., The Measurement of Adult Intelligence, 117
- Weeder, S. D. (Ed.), Bundy's Anatomy and Physiology, 494
- Wegener, Else (Ed.), Greenland Journey, 83
- Weiskotten, H. G., *et al.*, Medical Education in the United States 1934-1939, 389
- Weiss, Gertrude S., *et al.*, Family Income and Expenditures, 237
- Weiss, P., Principles of Development, 101
- Wellman, P. I., The Trampling Herd, 243
- Wells, R. G., and Perkins, J. S. (Compl.), New England Community Statistical Abstracts, 374
- Wendt, G., Science for the World of Tomorrow, 398
- Wheeler, L. R., Vitalism, 365
- Wheeler, W. M., 123
- Wigglesworth, V. B., The Principles of Insect Physiology, 250
- Wild, W., The Butterflies of the Niagara Frontier Region, 241
- Williams, J. F., A Textbook of Anatomy and Physiology, 101
- Williams, J. J., S. J., Thoughts on Evolution, 74, 224, 363
- Willis, L. G. (Compl.), Bibliography of References

- to the Literature on the Minor Elements and Their Relation to Plant and Animal Nutrition, 501
- Winkler, J. K., and Bromberg, W., Mind Explorers, 260
- Winslow, C. N., A Study of Experimentally Induced Competitive Behavior in the White Rat, 508
- Wishart, J., Field Trials, 381
- Wissler, C., Indians of the United States, 370
- Wolcott, R. H., Animal Biology, 486
- Wolf, B., Catalogue of Cave Fauna, 244
- Woodger, J. H., The Technique of Theory Construction, 229
- Wright, F. C., Population and Peace, 80
- Wright, W. D., The Perception of Light, 390
- Yapp, W. B., An Introduction to Animal Physiology, 105
- Yust, W. (Ed.), 1939 Britannica Book of the Year, 120
- 1940 Britannica Book of the Year, 512
- Zahl, P. A., To the Lost World, 86
- Zeuner, F. E., Fossil Orthoptera: Ensifera, 362
- Zimmermann, A. A., Origin and Development of the Lymphatic System in the Opossum (*Didelphys marsupialis* L. var. *virginiana* Kerr), 492
- Zoologica, 95, 252, 381, 483
- Zoology (book reviews), 92, 238, 376, 481
- Zuruckzoglu, St. (Ed.), Prevention of Congenitally Diseased Offspring, 105

AN AGRICULTURAL

$$\begin{array}{r} 7.6.62 \\ 23'12.66 \end{array}$$

•